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CONTENTS FOR NOVEMBER 1941

Vol. 22, No. 11

EDITORIALS

Basic Farm Building Research

To the Editor:

I WISH to offer some comments on Mr. Malcom's letter published under the above heading in AGRICULTURAL ENGINEERING for October.

It is a fact that there has been a great lack of basic research work by agricultural engineers in the farm structures field. Just recently at the University of Wisconsin we have set up a dairy barn research project to study the housing of dairy cattle, in connection with which we will do everything in our power to eliminate the variables, except one. As the work progresses, we hope to vary these variables, so as to give the cow the opportunity to demonstrate the type of barn in which she will be enabled to operate most profitably and efficiently. In fact, I am giving this project the greater share of my attention and time, fully realizing the great need for concentration in order to delve deeper into the problem and secure basic research information. Such information can then be used for designing dairy barns for this climate.

I have been very much interested in the possibility, suggested by Mr. Malcom, for the American Society of Agricultural Engineers to tackle the solution of the problem of cooperation between the states on farm building plans. The Midwest Farm Building Plan Service, so ably directed by Henry Giese, is an excellent example of such cooperation and appeals to me very much. However, the principal difficulty faced by the agricultural engineering staffs of land-grant colleges and universities is to sell their administrative officers on the idea of making it possible for staff members to devote sufficient time to revising the Midwest Plan Service catalog and keeping it up to date. It is important, also, that any such revision be backed up by basic research, which is so greatly inadequate to our present needs.

An illustration which I have frequently used as to what agricultural engineers in land-grant institutions might accomplish, if they were in position to do more basic research work, is in connection with the milk houses specified by the United States public milk ordinances. It would have been logical for agricultural engineers to have set the design requirements for those milk houses, rather than simply develop plans for the houses for which another agency has written specifications.

In his letter, Mr. Malcom suggests that a committee is needed in the Society to check experiment station bulletins prepared by agricultural engineering staff members, for the purpose of keeping to a minimum the number of statements which do not coincide. So far as the Society is concerned, I would say that we need a committee to check the titles of all papers before they are presented before Society meetings and even the papers themselves before they are published by the Society, so that we can develop a united front on all major issues and problems. In other words, it seems to me there is as much necessity of checking Society papers as there is of checking college bulletins.

Like Mr. Malcom, I am dubious as to the value of the usual biannual paper on poultry housing, based on someone's personal experience and ideas. Is it not time that we set up poultry housing standards to which we can all subscribe?

If it is not possible at this time to set up such standards, then the reason must be lack of basic research, perhaps as much as anything. Until such research can be conducted to provide the basic requirements, we must draw on experience for our information for poultry housing design, and we must admit there are many ways in which to design poultry houses, in so far as both plans and materials of construction are concerned.

When a type of house has been developed through many years of experience and hundreds or even thousands of these houses are in use on farms in the state, it must be admitted that it would probably be better business to build this standard house than to experiment with something new, unless the new house can be planned by a competent agricultural engineer to try out new ideas or to meet new or changing conditions. While each state has its own poultry house design, it must be remembered that even so we are getting efficient poultry housing and in the case of lumber construction, these variations in plans are neither objectionable nor do they particularly affect costs.

However, when it comes to the prefabricated house and its effective sales promotion, a standard plan is in demand and should be developed. Such a demand, however, will be met in due course, and I believe can be met through more extensive cooperation between agricultural engineers in industry and those on staffs of the land-grant institutions.

It seems to me that the latter group have done a pretty good job of pioneering work in the past, especially when it is realized that their job has been largely to open up a new field. At the same time, they have been under the handicap of limited budgets and usually are overloaded with work. They have traveled and visited farms by the thousands, made hundreds of "trouble-shooting" calls, but even with a lack of basic research they have made the best of the situation and got results.

S. A. WITZEL

Associate professor of agricultual engineering
University of Wisconsin

Notes from the President

To A.S.A.E. Members:

REALIZING the need to arouse greater interest in and to give more recognition to the activities of A.S.A.E. committees, this year your president has requested that each chairman of a committee — especially if it be one set up under one of the Society's five divisions — have a definite conviction that there is a job for that particular committee to do, a pretty good idea of what its job should be and how it should be tackled, what members are working in that field, and possibly what the committee might be able to contribute in the way of papers or reports during the year — all this before official appointment is made.

The purpose of all this is not only to stimulate better committee work in our Society, but also to forewarn division chairmen that worth-while contributions to meeting programs may be expected, in the form of technical papers or progress reports, so that the opportunity may be provided for featuring contributions from committees on our program, thereby enabling the committees to gain the recognition which their efforts merit.

On another page of this issue of AGRICULTURAL ENGINEERING will be found those committees functioning under our professional divisions that have completed their personnel, that have set up definite objectives and programs of work, and that have received notice of appointment or reappointment through the usual channel. This activity is progressing nicely, and other committees will be added to the list from time to time.

GEO. W. KABLE,
President, A.S.A.E.

AGRICULTURAL ENGINEERING

VOL. 22 NOVEMBER 1941 NO. 11

What Is New in Farm Machinery

By E. A. Silver

Member A.S.A.E.

THE PRESENT national emergency has curtailed to some extent new developments in agricultural machinery. Much individual ingenuity and materials of construction have had to be diverted into other channels. Nevertheless manufacturers of farm equipment are not standing idly by, but instead are striving to keep up the pace of development established in recent years.

No one can predict, with any degree of accuracy, what the future may hold forth; however, one thing is certain, namely, that the labor problem on the farm is becoming more and more serious and probably will become acute. This is bound to affect the all-important problem—production of food.

In order to meet the emergency, therefore, the farmer must be adequately equipped to solve this basic problem in the most efficient and timely manner. It is true that we have a big job in the maintenance and repair of machines now in service, but even though this is done in the most expert manner, it is very doubtful if it will be sufficient to meet the farmer's needs since many farm operations are yet in the crude stage of development, particularly in certain sections of the country.

In working out new developments the manufacturer is confronted with many problems. It takes time to work out and put into production new models, as well as improvements in existing machines. Futhermore, many materials of construction are now difficult to obtain, even though most of the farm equipment manufacturers are on the preferred list. Substitutes will have to be found in many instances. At this time it is extremely difficult to secure galvanized iron. Black iron or wood will have to take its place. Then there is the curtailment of such metals as copper, manganese, aluminum, nickel, and chromium which play no small part in the production of farm machinery. All of these problems naturally affect the present production of machines as well as future developments in mechanical equipment.

In bringing out new developments in farm machinery, the industry must be sure a need exists for such equipment and that it will be a profitable investment both for the farmer and the manufacturer. In order to recognize quickly the need for new development, industry must follow closely the trends in agriculture and determine on what fundamental facts these trends are based. It must be familiar with the fluctuation in the amounts of various crops grown and with revised methods of culture, processing, storage, and harvesting of these crops throughout the various states in which grown. The three agencies that should be closely allied with new developments in agricultural machinery are the agricultural experiment stations, the farm equipment manufacturers, and the farmers. With these agencies working closely together, progress would be faster.

There are two rather distinct areas for new development in farm equipment. First, we may have an entirely new method of doing a particular job, and, second, it may simply be a new principle applied to an old method. Before a new method is adopted in practice, much basic or fundamental knowledge or facts should be uncovered. Unless the new method is built upon a solid foundation, it will have little chance of lasting success. One of the principal reasons for this is that a new method usually involves new standards of processing whether it be soils or crops.

It is here that the agricultural experiment stations, through "pioneering" research, can contribute much to these developments by furnishing basic facts to industry to use or apply for the ultimate benefit of agriculture as a whole. A very good illustration of this lies in the preservation of green grass. This problem, in many sections of the country, is new and untried. Both preservation theories, and harvesting and processing methods have been drafted largely from past experiences, although a different kind of crop is being handled, particularly in regard to its physical structure. Before improved methods of handling and means of preserving grass silage can be satisfactorily developed, we need to know more about the factor of density and its relation to fermentation, the relation of dry matter to moisture, the effect of temperature, and many others. Other problems of similar nature are types of seedbed and rootbed and feed processing.

It is sometimes true that the development of a new machine may revolutionize certain practices in agriculture

Paper presented at a meeting of the North Atlantic Section of the American Society of Agricultural Engineers at Jackson's Mill, W. Va., October 1941. Author: Associate agricultural engineer, Ohio Agricultural Experiment Station.

and hence a new method may be developed. This may be questionable procedure, because it is a rather short range point of view and it may terminate very abruptly, because all of the basic considerations regarding its use and adaptability to agriculture may not have been observed.

A new principle applied to an old method may be of spontaneous origin and yet prove highly satisfactory, largely because of the lesser amount of fundamental or basic knowledge required. Good examples of new principles applied to an old method are the small straight-through combine, V-belt drives, the light-weight, fast-moving tractor, and rubber tires. All of these new developments of principle have certainly contributed much to agriculture.

In the design of a machine, a good designing engineer will try to analyze, in proper sequence, what the functional units of the machine should be. Then he will aim to place or locate these units in such order that the material passing through the machine will have the least and most direct possible distance to travel. Many times we see, particularly in a new machine, where the functional units are spread over a large frame with the processed material passing through these units from all directions and distances. A good example of direct connection lies in the new type of combine where the grain passes from the cutterbar to the cylinder, and to the straw racks and sieves in the most direct manner. This is vastly different from the older type machines.

The scope of new developments in farm machinery ranges far and wide. In order, therefore, to limit this paper, I have classified the machines into various areas according to function. The first of these is the tractor.

The revolutionary design of tractors which occurred some years ago is one of the most noteworthy achievements in the history of American agriculture. Back in 1918 and 1919 when college departments of agricultural engineering were conducting field as well as laboratory tests on tractors, few engineers would have ever dared to predict present models. In addition, farmers were very skeptical of their adaptability to farm work. A few years later, however, a few engineers of vision worked with and refined these old models until today we have a tractor of greater power per unit of weight, greater ease of handling and adaptability, and of greater strength because of improved design and the use of higher quality materials.

It is interesting to review some of these changes. The general design has multiplied tremendously the many farm tasks which can now be done by the tractor. Today the ease by which implements can be attached to and detached from a tractor has increased its use and lowered its cost. Furthermore, the ease by which these implements can be guided, raised, and lowered have all added to the efficiency of operation and convenience of the operator. These features have made the tractor a practically indispensable unit for the farm.

The development of the power take-off has brought about many new developments in power-driven implements. A few examples of these are small combine harvesters, corn pickers, potato diggers, and forage harvesters. In order to make this principle of transmitting power of more universal use, the American Society of Agricultural Engineers, through the recommendations of its Committee on Power Take-Off and Drawbar Hitch Simplification, has recently adopted standards in which the size spline, the location of the power take-off shaft in relation to the hitch point on the drawbar, the thickness and strength of the drawbar, the diameter of the hitch hole, and the distance of the drawbar from the ground, have all been standardized. The power take-off speed is standardized at 536 rpm $\pm$ 10 rpm. It is also required that shields over the power-line shafts be provided. These new standards have solved a perplexing problem which has existed for some time and which will now make it possible for any make of tractor to be connected to any make of implement with a minimum of effort and safety.

A great need has existed for a dynamometer to record the power delivered through the power take-off shaft. Quite recently such a device has been developed in the department of agricultural engineering at Ohio State University. This dynamometer will measure and record both the power through the power take-off shaft and the drawbar pull of the implement or machine. It was used successfully this past season to measure the power of grain combines in actual field operating conditions. This device fills a long-felt need for determining the power requirements of power take-off driven machines.

Seed and Rootbed Preparation. In the area of seed and rootbed preparation few new developments have been uncovered. Perhaps this is due to the fact that as yet we do not know what the proper type of root and seedbed should be. There is one noticeable tendency, however, in that we are getting away from pulverizing the top soil. The disk harrow which has been so popular in the past, is being

Not only are there a multitude of needs to be found on American farms for farm machinery and a great variety of kinds and types of implements and machines essential to meet these needs, but there are also a great many conditions, both favorable and adverse, under which this equipment must operate, and operate successfully. Indeed the requirements of farm machines are such as to call for the very best engineering talent possible to produce equipment that will meet these requirements in the most satisfactory manner. Considering all aspects of the problem, it is not too much to say that farm machinery engineering on the whole is as fine an example of engineering development as can be found anywhere

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Two-way plows are coming into use, particularly in areas where contour farming is practiced. Although not a recent development, disk coulters have shown to advantage particularly in the covering of excessive surface trash.

Seeding and Planting. In the seeding and planting area, again few new developments have appeared. Certain refinements have been made on grain drills, particularly in general construction, such as all-steel waterproof boxes. In order to meet the higher speeds of tractors, corn planters are receiving much attention. Valves and runners are being redesigned to assure an accurate check at the higher speeds. Other features are also receiving attention.

Cultivation. Cultivators have received only minor attention recently. Improvements have been chiefly along the line of ease in operation and in the types of shovels. The rotary hoe has been improved by the sectional type of construction, which makes it more adaptable to higher speeds and uneven ground surface.

Harvesting. In no other area has there been greater progress than in harvesting, at least within the last ten or fifteen years, and in no other is there so many methods to do the same job, particularly in the field of forage harvesting. Much has yet to be done particularly in the harvesting and storage of green forage crops.

THE DEVELOPMENT OF MORE SUITABLE EQUIPMENT FOR HARVESTING THE HAY CROP IS PROGRESSING

One of the most promising developments in haying equipment in recent years has been the small pickup baler. Although this method of putting up hay has been in use for several years, some very significant changes have been made on these machines very recently. "Save the leaves" is a slogan in haymaking and the pick-up baler has at least partially met the challenge. Speed in the hay field is another factor to which the pickup baler has contributed. These machines are now lower in price and have many new principles which have improved their operation. They are small and compact and can be used for baling straw from the combine as well as baling from the stack.

Further developments are still in evidence. The windrow is now to be rolled up, similar to the rolling up of a carpet, tied with twine when a 70-lb roll is secured and dropped at the rear of the machine either on to the ground or on to a wagon. This is a new principle fully automatic and is a good example of correct placement of the functional units of a machine previously mentioned in this paper. Tying bales with twine is not new as some makes of balers have been using this principle for years.

In order to facilitate the curing of crops for hay a machine was developed a few years ago which would crush the stems, and expose the moisture for rapid evaporation. This machine seemed to have a lot of merit particularly from the standpoint of shortening the wilting period.

Mowers have been redesigned for greater strength, longer life, and greater simplicity. Gears are now running in oil, and in some venturesome cases have been entirely eliminated. The frame and means of attachment to tractors have been greatly simplified. V belts are coming in as the major link of power transmission from the tractor to the mower.

The field forage harvester is one of the most recent developments. It is an entirely new method, particularly in the harvesting of green forage. The development of this machine is therefore dependent a great deal upon the many fundamental crop factors. For instance, in harvesting green forage we must have a positive answer in regard to the moisture-dry matter relationship of the crop for best preservation. We also need to know how and to what degree the material should be processed. These factors will determine the functional units of the machine, particularly in regard to whether the crop is to be processed immediately after cutting or cut and allowed to wilt, and to what extent.

Some of the more receptive scientists feel that it may be possible in the future to preserve green grass without the use of additional preservatives. If this can be done, it will indeed facilitate the ease of handling this material and may affect to a considerable extent the method of preservation.

Until the development of the forage harvester for grass silage, farmers have been compelled to adapt equipment designed to handle wilted material. Breakages and delays have resulted. Considerable trouble has been experienced with hay loaders. In order to meet the additional strains all loaders have been strengthened. Slats, rake bars, chains, and bottoms have been made heavier. Farmers are now using these heavier machines for hay as well as for green grass.

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Many recent refinements have been made on corn pickers, a machine which is really open to many new principles of design. Rubber on the snapping and husking rolls is coming into use. Future machines will appear to have lost much weight, and in the case of the mounted models attachment to and detachment from the tractor will be greatly simplified. Much attention has been given to the snapping rolls in order to reduce shelling at that point. Some have placed the rolls more nearly horizontal; others have adopted only one spiral snapping roll working in conjunction with a snapping angle and pressed steel chain. Others are using shields over the top of the snapping rolls to prevent the ears from getting down between them.

The most revolutionary changes in combines occurred a few years ago when the straight-through principle was developed. Several minor changes have been made since, which include the all-important principle of quick-change cylinder speed. This is very necessary for harvesting various kinds of crops, and conditions within any one crop. Another similar development is badly needed in a quick, accurate adjustment for clearance between cylinder and concaves or shelling bar. We need this in order to prevent cracking of grain, breaking up of the straw for more efficient separation of the grain, and to decrease power requirements when necessary. Another, yet very important development is the hand lever adjustment of the reel. Handling straw back of the combine is *(Continued on page 385)*

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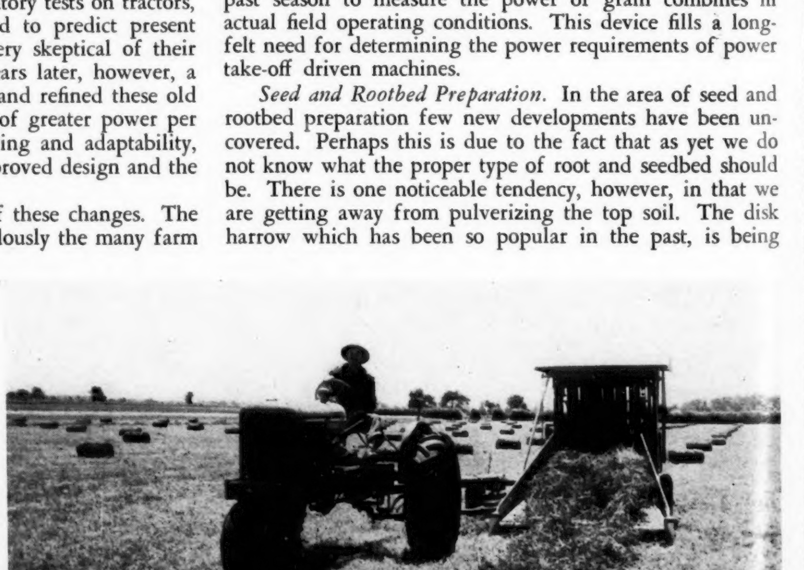

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Gravel-Rock Overfall Structures

By Thurman P. Powell
MEMBER A.S.A.E.

ROCK ALONG the course of mountain streams form themselves into overfalls which often remain unchanged for long periods. Men have tried to emulate nature in this respect but not always with success. In the last few years, the necessity of having gravel in conjunction with rock has become more generally appreciated, but methods for getting a gradiation of materials have been clumsy while calling for the use of huge quantities of rock and aggregate.

The problem of getting a successful system for constructing loose rock overfall structures that will be economical of materials, and which does not require the skill of an artisan truly is one worthy of solution. The method here described has been quite successfully used for irrigation drops on the generally sandy soil of the Stanfield-Umatilla (Oregon) area. It is economical of materials and requires only intelligent attention to detail, while structures can be built by this method in a relatively short time. A CCC enrollee after helping in the construction of two irrigation drops, was required to make the excavation and completely build a 2.5-ft drop alone. He did this in six hours and the structure has stood up without change during the past two irrigation seasons. I timed myself as part of a routine in the first placements made by this method following experimental work, and with two CCC boys was never more than 2½ hr in the actual laying of each of ten rock drops. Some of these had a drop of over 3 ft while only three had drops of less than 2 ft.

Irrigation streams flowing over rock structures built by this method have ranged in size from 1 to 5 sec-ft. Failures have been few, and those occurring were made correct by relaying the rock and placing gravel following the principles as are here set forth.

Detailed measurements of materials have been made in a few cases and rough measurements in many. A 1-ft drop with a 3-ft spill width should go in with the use of approximately a yard of gravel and 1½ yd of rock. The amount of materials for a structure of greater height is only slightly more. Rock for this use may either be angular or river wash. Two parallel faces are preferred though not essential. In general, rock with a thickness of one-third its long dimension is about right, but I have found that structures can be made from practically any commonly occurring shapes as long as the general size is good and there is some variety. A larger amount of small material is necessary where less desirable rock is used. Use of a stone hammer is not essential. Rock as used seldom exceeded 100 lb in weight, while the general run weighed from 20 to 50 lb. The very small irregular rock which would be included in most haulings is disposed of by placing behind the overfall.

Following are the essential requirements of a loose-rock structure where earth is being protected from flowing water:

1 A gravel filter to prevent soil from being washed from underneath the rocks or made to pipe through be-

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CONSTRUCTION AND EXAMPLES OF GRAVEL-ROCK OVERFALL STRUCTURES

A completed gravel-rock overfall structure (1) built for test purposes. No structure failed where the V principle of laying rock was correctly followed. Such a structure should prove of value for terrace outlets as well as in irrigation practice • To get the proper gravel filter for protecting the soil, in building a rock overfall structure, foot-deep trenches spaced 12 to 14 in apart (3) are first dug and filled with gravel • Lack of gravel on the sides is more apt to cause trouble than elsewhere. A 2-in overall layer of gravel is hard to place as it will slide down the sides; tamping gravel behind a timber (2) makes it less difficult. The sides preferably slope 1.5 to 1, and never steeper than 1 to 1 • (4) The first layer of rock laid for the structure. Note the V crevices opening upstream, and the coarse gravel in some. A wheelbarrow full of gravel is kept near • (5) In this completed structure the spillway is unnecessarily wide. The water should be forced toward the center, as the sides are not as strong • (6) The drop in this structure was made especially long and "stepped", which was found not to be necessary • (7) This structure shows the possibility of loose rock spillways for farm reservoirs. It has a 10.4 ft fall in 68 ft. The stream flow is 1.5 cfs

tween them, and to allow water at a minimum velocity to penetrate the system.

2 Rock of sufficient size placed so as to furnish an overfall surface and to retain the filtering material.

3 The proper placing of spalls and large gravel in the rock crevices to retain the finer materials and to aid in keeping a flow of water from penetrating the system.

These requirements are met in structure as follows: (1) In order to be able to protect the soil, and especially soil heavy in clay and colloids, a very effective filter is needed. This filter is obtained by making the excavation for the drop with a 4:1 slope on the channel bottom and placing gravel-filled trenches across it at close intervals. Then similar trenches are dug along the sides and filled with gravel, after which a 2-in overall layer of gravel is placed. In this way a 12-in filter can be secured with the use of not more than one-quarter of that much material. And whereas, in the case of a homogenous filter, a trickle of water carrying a small quantity of earth is followed by an increase in the flow of water with a corresponding increase in the removal of earth, with a filter of differing materials the removal of small quantities of the finer means the eventual clogging of the coarser with a lessening of its filtering tolerance. (2) The surface is shingled with a single layer of rock except at the overfall. Some skill must be exercised in getting the rocks balanced, in breaking the joints, in selecting rock for particular places, and in getting the V placements as described later. When the apron has been laid a transition is brought about from the upright placing of rock to a horizontal one for the overfall. Here a double layer of rock is used and with small and odd-shaped rock together with gravel dumped behind it to completely fill the space provided. (3) The proper placing of intermediate size material is of great importance. Every rock is placed with it in mind. Place rock with a downstream edge touching that of another and with as large a V crevice as possible opening upstream. On the ditch sides these Vs open toward the surface. Fill this crevice with graded material being sure that large gravel that can not come out block any opening between the rocks. Do not rely on one rock to jam a crevice but put in several of a similar size.

LARGE ROCK PLACED SO THAT GRADED MATERIAL IN CREVICES HOLDS THE ROCK IN PLACE

This system of large rock placed so that the graded material filling its crevices are held in place, and with a gravel layer protecting the earth, should produce a stable structure. A portion of the water's velocity is dispersed because of its striking the face of the large rock and the remainder is kept out of the system by the coarse gravel blocking the crevices and preventing water in a stream from penetrating.

In getting the 2-in overall layer of gravel on the ditch sides, lay a 6x8-in timber along the side and spread gravel behind it. Tamp it in, move the timber, repeat the process.

Begin the strucure by laying rock at the downstream toe of the excavation and incline a layer of rock downstream and against a gravel prepared slope. Continue with successive layers of rock after filling all irregularities of the previous layer with small stones and finishing with gravel. The layers for the bottom are brought well up the ditch sides and a square-shouldered rock placed so as to brace those laid higher up. Save the heavy flat rock for making the overfall.

Place no rock over which water will flow without there being gravel under it to protect the soil.

What Is New in Farm Machinery

(Continued from page 383)

still a serious problem, both from the standpoint of plowing it under and for bedding purposes. We need to know more of the value and utility of straw when it is left on the ground.

Recently a new principle of propulsion has been developed for the larger combines. This is the self-propelled combine whereby an engine mounted on the combine propels the machine as well as furnishes power for the various operating parts of the machine itself.

In harvesting the potato crop we certainly need some new principle or even a method. A survey made by the Ohio station showed damage to potatoes by present type diggers of from one to as high as twenty-five per cent. This damage includes cut and bruised potatoes. Present type diggers require an excessive amount of power and are very ineffective where the ground is very dry and hard or when very wet. To meet these conditions a new development has appeared in providing for an adjustment to raise or lower the apron. For dry conditions the apron is lowered, and raised for wet conditions where separation is difficult.

TRANSPORTING HAY FROM FIELD IS STILL A RATHER PERPLEXING ENGINEERING PROBLEM

Miscellaneous. Transporting hay either to the barn or to the baler or stack in the field has remained a rather perplexing problem. And now with heavy green grass to be handled, the problem is aggravated still further. In many sections buck rakes have been in great demand and have been found to be very practicable in many instances, particularly in the collection and transportation of hay. Many farmers have become interested in these machines and are building them for their own use from plans issued through some of the agricultural extension departments. A member of our agricultural engineering staff at Ohio State University has been very active in the design of these machines. Many are constructed on the back of old trucks. Others are mounted in front of the tractor and the weight carried on two separate wheels. These machines are finding a use in bringing green grass to the silo, as well as for haying purposes.

Because of the greater acreage of forage crops, lime is being used in increasing quantity. The problem has arisen with regard to transporting and spreading this material. Devices for this purpose are being rapidly developed and seem to have considerable merit.

The question of elevating green grass into silos is still a big problem. The agricultural engineers of New Jersey Experiment Station have been working with this for some time.

Quite recently a most noteworthy achievement has been in the development of a rapid moisture determinator for green forage, grains, etc., something which the farmer, elevator men, dehydrators, and others can use, and which can be obtained at a nominal cost.

There are many other new developments in farm machinery that could be mentioned. Many of them have just as much merit as those mentioned in this paper, but unfortunately time does not permit discussing them. Looking back over the years, tremendous progress indeed has been made in new developments in agricultural machinery; the saturation point, however, has not yet been reached by a long ways.

Machinery for Sweet Potato Production

By John W. Randolph
MEMBER A.S.A.E.

CHEMICAL research and applied engineering have found methods of making important commercial products from the sweet potato. At this time, the extensive industrial utilization of this crop is being delayed by two major factors, namely, (1) the rapid rate of deterioration of the harvested crop and (2) the relatively high cost of raw material in comparison with the prices that can be obtained for the products.

The federal government, realizing the many problems connected with the establishment of an industrial outlet for sweet potatoes, has given different forms of material assistance. Paine, Thurber, and others[1]* of the agricultural chemical research division of the Bureau of Agricultural Chemistry and Engineering, U. S. Department of Agriculture, have developed suitable processes for making white sweet potato starch. At Laurel, Mississippi, the Farm Security Administration has sponsored a farm cooperative as the manufacturer. Through the payment of a subsidy, the Surplus Marketing Administration has encouraged neighboring farmers to grow sweet potatoes for starch production.

The commercial acceptance, the increasing demand, and the premium prices received for the sweet potato starch made by the Laurel starch plant have justified the Department's expectations as to the quality of the product and its possible substitution for imported root starches.

The results on the farm side of the new project are not so bright, and they are somewhat confusing. Ware[2] and others have proved that the sweet potato crop has a high potential industrial value due to its adaptability to southern field conditions, its dependability, and its high yield capacity. In actual practice the average production of sweet potatoes is low because the farmer generally grows the crop for his own needs. The average yield was approximately 75 bu per acre in the Laurel area before the erection of the Laurel starch plant. In recent years there has been a remarkable improvement in production per acre. Many farmers now average 250 bu per acre. Still the average acreage per farm is low; hence, 1075 members of the cooperative in 1939 and 992 members in 1940 failed to produce 350,000 bu, the seasonal capacity of the Laurel factory.

Recent analyses indicate that a sweet potato starch factory should have a seasonal capacity of 750,000 to 1,000,000 bu to lower the unit cost of manufacture and make the finished product's value exceed all items of cost. When the Laurel plant was set up, it was estimated that a price of 20c per bu could be paid for sweet potatoes on the basis of a 100-day operating season. Conditions have not materially changed from that time with regard to price based upon normal starch content and values. Under war conditions or the availability of new varieties of sweet potatoes with a higher percentage of starch, the price paid to farmers can be more. The 1941 starch plant price will be 15c paid by the factory, plus 12½c subsidy from the AAA, and possibly plus 2c bonus to be paid by the factory, if the total production of the cooperatives exceeds 325,000 bu.

Guin and others[3] of the Mississippi Agricultural Experiment Station found by a 1939 survey of selected farmers that the average cost of production of sweet potatoes was 25c per bu. This cost was based upon an average of 5.7 acres in sweet potatoes on the farms surveyed, with an average yield of 166 bu per acre.

There is increasing interest in the possibilities of dehydrated sweet potatoes in the form of meal or cossettes, due to local shortages of carbohydrate feeds and the superior value of the meal as shown by feeding tests conducted by several southern agricultural experiment stations. Normal starch prices, prices for livestock in competitive markets, and crop processing costs indicate that sweet potatoes must be grown and delivered for 10 to 15c per bu if there is to be a profit in each part of a balanced sweet-potato-growing and stock-raising farm program. These figures are a challenge to the ingenuity of the agricultural engineer, the farm machinery manufacturer, and the farmer.

Significant improvements have been made by 61 cooperators in their farm management and in the production of sweet potatoes. These few growers differ from the mass of 1 to 3-acre producers by having not less than 10 acres of sweet potatoes with high average yields. The results of such larger-scale production combined with the use of specially developed equipment, indicate that the growers will eventually produce the crop at a price which will insure a profit to both the producer and the processor. It takes time to gain experience and develop suitable equipment for large-scale production of sweet potatoes, which heretofore have been grown by cultural methods designed to limit the yield in order to have uniform-shaped, small potatoes. My intention is to summarize here some of the changes, adaptations, and new ideas connected with the production of starch-making sweet potatoes.

Seedbed Preparation. Seedbed preparation for sweet potatoes has given the cotton farmer no special problem. For the most part, the methods and equipment commonly used for cotton have been found suitable. However, in practice, the small power units available have limited such work to shallow tillage, which, with other factors, has developed a definite plow sole and kept down the yields of the root crop. Preliminary results indicate marked advantages for the general-purpose tractor equipped with standard cotton-tillage implements. The major difference to be considered in the use of the tractor cotton-tillage equipment to prepare soil for sweet potatoes instead of cotton is that sweet potatoes need a high bed during the entire growing season, whereas cotton beds are comparatively low.

Transplanting. The transplanting season is the most difficult period for a cotton farmer who attempts to grow a large acreage of sweet potatoes. The new crop diversification programs have piled up a whole series of "must" jobs which should be done about the same time. Plowing under winter legumes, harvesting oats, chopping cotton, sowing summer hay crops, all combined with the usual cultivations, leave little time for sweet potato transplanting.

Most growers use a minimum-size hotbed for the propagation of their sweet potato plants. Hence, a limited supply

Paper presented before the Power and Machinery Division at the annual meeting of the American Society of Agricultural Engineers at Knoxville, Tenn., June 1941. Author: Agricultural engineer, Bureau of Agricultural Chemistry and Engineering, U. S. Department of Agriculture.

*Superscript figures refer to bibliography appended to this paper.

of plants at any one time tends to prolong the transplanting work from six to ten weeks. The limited planting material may also prevent planting in the field during favorable moisture conditions.

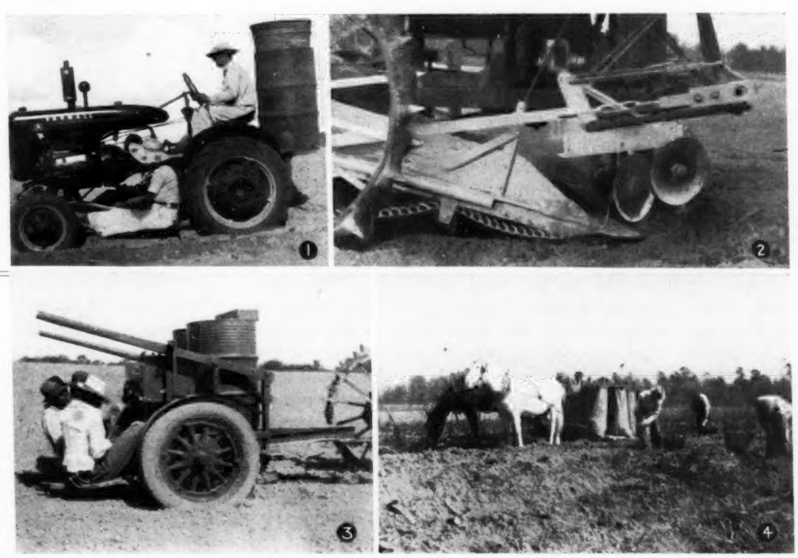
Horticulturists and heating engineers are working together on the problems of sweet potato plant production. The U.S.D.A. Bureau of Plant Industry and cooperating southeastern agricultural experiment stations have new varieties of sweet potatoes which may prove superior to the Triumph, now commonly grown, in plant production and in characteristics needed for industrial utilization. Anderson[4,5] of the Mississippi Agricultural Experiment Station has developed improved methods of sweet potato plant production.

Through the use of existing information and suitable homemade equipment, a few Laurel growers have demonstrated that it is possible to reduce the plant cost per acre to about $3.00 in contrast to $17.50 when plants from commercial sources are used in typical close spacing in the row.

The common hand method of transplanting is to drop the plants on the bedded and fertilized row, push the roots into the soil with a notched stick and then compact the soil with the foot. Sweet potatoes grown for the commercial market are closely spaced, from 6 to 12 in apart in the row, to force the production of many small roots. There is no maximum-size limit for industrial and feed outlets. Therefore, as an economy in seed stock, the plant spacings now range from 16 to 30 in in the Laurel area. The labor requirements for hand transplanting vary from 20 to 30 man-hours per acre. These figures may be doubled if water is applied to the transplants.

Only a few of the one-row, horse-drawn mechanical transplanters sold to the Laurel growers have been used in planting a major part of the owner's crop. The general criticisms of these machines are that the usual farm labor cannot do accurate work and that small mules cannot pull the machine at a uniform speed. Hillsides and terraces make unfavorable conditions for the operation of this machine which is designed for level fields.

Three types of experimental transplanters were used in 1941. These were (1) a direct tractor-mounted, one-row unit which was especially satisfactory on small and terraced fields (the location of the plant-setter in front of the driver permits full control of the planting operation); (2) a two-row experimental unit with a capacity of 3/4 to 1 acre per hour, which is pulled by a tractor and combines the operations of bedding, fertilizer application, and transplanting; and (3) a one-row, horse-drawn machine having equipment similar to that of the second one mentioned.



Four views of mechanical equipment used for the production and harvesting of the sweet potato crop • (1) A tractor-mounted sweet potato transplanter • (2) Close-up showing vine cutters on a sweet potato digger • (3) Two-row transplanter, bedding and fertilizer attachments on tractor • (4) Bagging cart used in harvesting sweet potatoes for starch manufacture

Getting and handling water for transplanting still remains an important item of cost. The small operator usually cannot afford a special water tank and pump on a wagon or truck. The large operator must give serious attention to having water convenient and use it in abundance to reduce the cost of replanting.

The care used in preparing and keeping planting material for use on a transplanter influences not only accuracy in transplanting but also the early rate of growth. The plants should be separated, culled, and trimmed at the bed and then packed so as to prevent wilting and tangling before their transfer to the machine.

Cultivation. Apparently the objectives of sweet potato cultivation are simply to keep down weeds and to continue to build up the ridge. The first cultivation is generally deep and close to the plants so as to cover the weeds in the row. Cultivations which follow are rather shallow. Sweeps shaped to fit the ridge, are used to work the soil from the middle into the bed. Some farmers use the middlebuster to "lay by" the crop. The one-mule, two-row rotary hoe has been used with some advantage in the reduction of manual cultivation.

Harvesting. The direct industrial utilization of the sweet potato brings up a series of harvesting problems new to a cotton farmer. From the standpoint of the factory there must be an orderly supply of fresh raw material. The typical grower has many reasons why he cannot take his "turn-at-the-mill" to make a long efficient processing season. The date of maturity of sweet potatoes does not materially complicate the program. Early-planted sweet potatoes have made satisfactory yields by the middle of August. Hoffman[6] of the Bureau of Plant Industry has found that the normal period of factory operation can be extended by means of field storage or delayed digging. The crop processing season may be 100 to 130 days at Laurel.

The direct industrial utilization of the sweet potato gives the farmer a great latitude with regard to the physical condition of the delivered crop. Dirt, "strings" or enlarged roots, and rot are the only restrictions. Rough handling, which gives an opportunity for the development of high-capacity digging and transportation operations, is permissible.

The growers in the Laurel area have made many improvements resulting in lower harvesting costs. The old

practice of hoeing or pulling the vines off the rows to aid digging is seldom used. Splitting the row once with the 12 or 14-in middlebuster equipped with a rolling coulter has replaced the former practice of running on each row four to six plow furrows for an equal number of hand-gathering operations. The middlebuster combination only partially exposes the sweet potatoes. Often the land is harrowed or replowed to finish gathering the crop. The general efficiency of the middlebusters can be improved by the use of rod wings developed by Jones and Anderson of the Mississippi Agricultural Experiment Station. In one case the one-row tractor equipment has been modified by using disk hillers on the front part of the cultivator to get the vine growth out of the way and by using 22-in point and rod wings on the middlebuster frame to separate the sweet potatoes from the soil.

The conventional, rod type, mechanical white potato digger is not adapted for digging sweet potatoes when the vines are green and rank. Fair results have been obtained with this mechanical digger when the vines were previously hoed from the row. The equivalent of these operations has been obtained by pulling the digger with a tractor equipped with an A-frame vine cutter. This vine cutter is a special disk-hiller attachment on a standard cultivator frame. It was most effective when fitted with four or six hillers and so mounted that the vines and surface dirt over the sweet potatoes were plowed into the middles.

Two experimental mechanical diggers have been developed by the Bureau of Agricultural Chemistry and Engineering. One is a direct-mounted tractor unit which was extensively used during the past two seasons with excellent results. In 1939, in one field previously harvested with mule equipment, this unit gathered an additional 30 to 35 bu per acre, which was equivalent to 15 to 22 per cent increased yield. The other machine, used only in 1940, was a combination digger and truck loader. This new digger will require further development and testing to determine its merit.

Collecting Sweet Potatoes. More than 90 per cent of the sweet potatoes purchased by the Laurel plant are delivered in bags. In the earlier years of this factory's operation, the bags were carefully filled by individual packing similar to that used in filling crates with table stock. It is now common practice to throw the potatoes into a "heap row" made up from potatoes collected from three to five adjacent rows. The gatherers then drag bags along this row and collect the potatoes.

The bagging-sled has now become a common piece of farm equipment in the Laurel area. It carries two to four open bags and is hauled along the dug rows by a team of mules so the gatherers can throw the potatoes directly into the bag in place of the usual heap row. This direct bagging has greatly reduced the time and labor required. Interlocking by proper arrangement of filled bags on the truck or wagon has eliminated an old practice of fastening the open end of the bag.

An experimental rubber-tired cart has been found preferable to the sled because a greater number of bags can be handled and pulled to the "turn row" with the same mule power. The assembly of the crop at the edge of the field, made possible by the cart, tends to lower the transportation charges from the farm to the mill.

A further reduction in gathering costs has been made by collecting the sweet potatoes directly from the row in wire baskets. After the baskets are filled, they are carried directly to the bagging cart or sled and emptied into the bags. A field foreman can obtain greater labor efficiency from a large group of workers by using the number of baskets gathered as the basis of wages and by applying penalties for potatoes left on the ground by the workers.

Transportation. The farm wagon and the small auto truck were the common vehicles used for transportation of sweet potatoes in the first years of the Laurel plant. In 1940 the greater part of the crop was hauled on large commercial trucks. This shifting of the hauling operations to a few units has helped to control the rate of delivery, essential for efficient operation of the factory. This coming season a part of the crop from farms 40 to 200 miles from Laurel will be shipped in box or cattle cars. The railroad shipments will not only help to regulate the harvest but give distant cooperators equal advantages with local growers.

The loose sweet potatoes in railroad cars and in the factory bins, filled from farmers' trucks, are shoveled into a flume leading to the washer. Washing is the first factory process. The many possible adaptations of the flume and washer system will permit further developments in the equipment and methods used in harvesting and hauling to the factory.

Possible Changes. Large-scale programs of sweet potato production will require the organization of special crews of men and special equipment for the production of plants, transplanting operations, and the collecting and storage of seed stock. Other production operations can be conducted with more or less standard equipment and regular farm labor.

Farmers will take advantage of the latitude allowed by the processing plant with regard to the condition of delivered sweet potatoes through cooperative use, in rotation, of a limited supply of equipment to save costs. Small cooperators would naturally use low-cost units, while on large-scale operations there would be need for special equipment such as a combine digger and truck loader and other units.

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Engineering Side of Chemurgy

A STUDY of certain chemurgic enterprises which have not succeeded, together with a review of possible new chemurgic industries, clearly indicates the importance of such activities as low-cost production of the agricultural commodities to be employed, dependable and satisfactory growing, harvesting, or gathering methods and machines, preliminary processing on the farm, and dependable delivery of raw materials at prices which make possible industrial utilization. A few bushels of agricultural material, such as castor beans or a bale of straw, is sufficient to allow a trained chemist to determine potential uses of great significance. Upon the results of his tests predictions may be made which receive great publicity and arouse hope. But until the agricultural engineering work is well done, millions of tons of farm products will remain unutilized and the consumer deprived of the use of new articles and commodities.

Radiation in Agriculture

By J. P. Ditchman

MEMBER A.S.A.E.

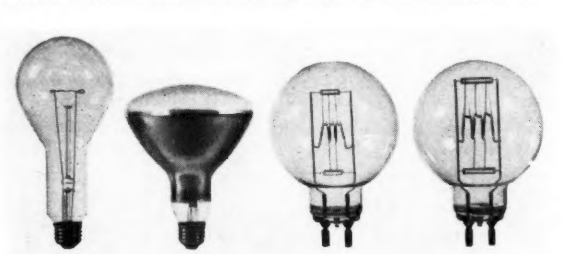
DURING the past few years much has been written concerning the uses of radiant energy for animal husbandry. Researches dealing with light for stimulating egg production, ultraviolet for the production of vitamin D, germicidal lamps for killing air-borne bacteria, and infrared for brooding purposes have all been discussed. More recently infrared radiation is being used for brooding purposes as well as for the dehydration of various agricultural crops and other miscellaneous heat-treatments.

With this increasing use of radiant energy in agriculture, it seems timely to review some of the sources of radiation available so that the proper selection of the units may be made for definite jobs requiring certain wave bands.

The portion of the input which is radiated in each of certain broad regions of the spectrum by gaseous discharge lamps of various types is given in Table 1.

Table 2 gives the proportions of the input which are radiated in certain wavelength bands for 18-in Mazda fluorescent lamps one inch in diameter. For the longer fluorescent lamps the spectral distribution of the radiated energy is practically the same, but the percentage of the input which is radiated in each band is somewhat greater because the overall luminous efficiencies of these lamps are greater than those of the corresponding 18-in lamps. The highest efficiency is obtained with the 48-in 40-w lamp.

Paper to be presented before the Rural Electric Division at the fall meeting of the American Society of Agricultural Engineers at Chicago, December 1941. Author: Illuminating engineer, General Electric Co.



Types of Mazda tungsten-filament lamps used in brooders and for dehydrating various farm crops. They also provide a quick means of drying farm equipment after repainting. The two lamps on the left are 250-w; those on the right 500 and 1,000-w, respectively

In Table 3 are listed percentages of the input wattages which are radiated in certain wavelength bands by the filaments of various tungsten lamps and which are transmitted through the bulb. The luminous efficiency and the color temperatures are given for each type.

Table 4 lists, for three markedly different conditions of observation, the distribution among various wavelength bands of solar radiation as received at the earth's surface.

One of the most interesting lamps of this group is the relatively new AH-6 lamp (listed as H-6 in Table 1) a water-cooled quartz mercury lamp. This lamp is rated at 1000 w, and with its auxiliaries it consumes approximately 1200 w. The lamp consists of a quartz capillary tube about 1½ in long having an outside diameter of about ¼ in and a bore of about 3/32 in. Sealed into each end is a tungsten wire which serves both as electrode and lead. The tips of these wires project through the surface of a small mercury pool at each end of the lamp. The lamp reaches full output in about 1 or 2 sec after power is applied. As the heat from the argon arc quickly vaporizes the mercury, the pressure builds up to about 80 atm (atmospheres), or some 1200 lb per sq in.

Because of the high wattage in such a small volume it is necessary that water be passed over the quartz tube fast enough to prevent the formation of steam bubbles on its surface. To accomplish this a "velocity tube" is placed around the lamp with a very small radial clearance through which the water must flow. Because the cross section of the water path is restricted, sufficient velocity is attained with a water flow of about 3 qt per min, and the temperature of the water increases only a few degrees in passing over the lamps. Recirculating cooling systems employing a pump and a radiator have been built. Seventy-seven per cent of the lamp energy other than the visible light is carried off by the circulating water, making the coolness of the resulting radiation one of the lamp's valuable characteristics.

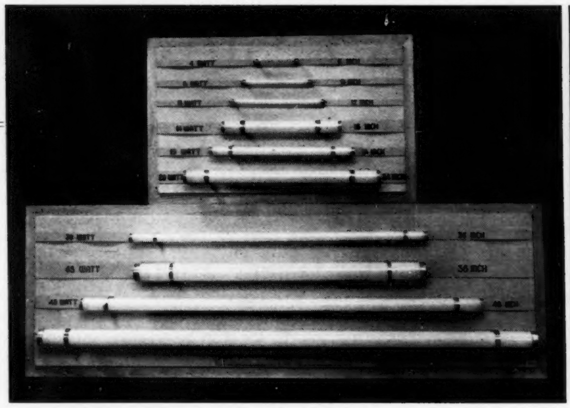
The lamp produces about 65,000 l (lumens) with a maximum surface brightness of 195,000 c (candles) per sq in, or one-fifth the brightness of the sun. Because the heat storage is small and the tube cools rapidly, the AH-6 lamp may be restarted at once. The rated life of the lamp is 75 hr. This is based on tests employing 25-min burning periods. The average life of these lamps is affected by the

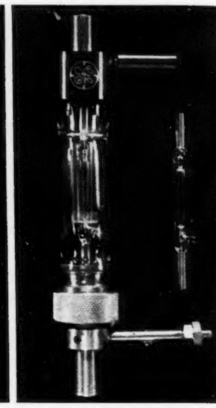
TABLE 1. PER CENT OF OVERALL INPUT RADIATED IN DIFFERENT SPECTRAL BANDS BY VARIOUS GASEOUS-DISCHARGE LAMPS MANUFACTURED BY THE GENERAL ELECTRIC COMPANY

				WAVELENGTHS IN ANGSTROMS								Ultra-violet	Visible	Infra-red
												WAVELENGTHS IN ANGSTROMS		
Type of lamp	Vapor or gas	Bulb glass*	Overall input, w	Less than 2800	2800 to 3165	3165 to 3800	3800 to 5000	5000 to 6000	6000 to 7600	7600 to 14,000	14,000 to 26,000	Less than 3800	3800 to 7600	7600 to 26,000
NA-9	Na		260	0.00	0.00	0.01	0.00	7.4	0.48	1.93	4.8	0.01	7.9	6.7
AC-6T7U1	Ne		415	.00	.00	.01	.00	4.7	5.1	5.0	.00	.01	9.8	5.0
H-1	Hg	772	456	.00	.00	.93	3.1	5.9	.24	4.8	5.9	.93	9.3	10.7
H-2	Hg	172	294	.00	.00	.79	2.5	4.0	.29	2.8	3.1	.79	6.8	5.9
H-3	Hg	772	105	.00	.08	2.9	4.8	5.0	.94	4.4	7.0	3.0	10.8	11.4
H-4	Hg	772	120	.00	.04	2.6	4.5	5.5	.82	5.1	9.0	2.6	10.8	14.1
H-5	Hg	774	298	.00	.15	3.0	4.6	6.5	1.14	6.1	6.7	3.1	12.2	12.8
H-6	Hg	774	1170	.00	.42	5.3	12.1	8.5	3.0	6.1	.00	5.7	23.6	6.1
H-6	Hg	Quartz	1170	3.3	5.6	8.0	12.6	8.8	3.0	7.9	2.1	16.9	24.4	10.0
UA32A2	Hg	Quartz	696	8.0	6.5	5.7	5.0	7.3	.68	4.4	2.9	20.1	13.0	7.3
UA26A2	Hg	Quartz	417	4.5	4.3	3.7	3.2	4.1	.18	1.05	.65	12.5	7.5	1.70
15-w Germicidal	Hg	972	17.5	8.4	.22	.19	1.62	.67	.01	.01	.00	8.8	2.3	.01
S-1†	Hg	776	438	.00	.38	.58	.93	1.63	3.3	19.7	19.4	.96	5.86	39.1
S-2†	Hg	776	145	.00	.21	.32	.57	.92	1.70	10.3	11.2	.53	3.2	21.5
S-4	Hg	776	124	.02	1.9	3.5	4.4	5.3	.79	4.9	8.7	5.5	10.5	13.6
G-1	Hg	776	46	.00	.31	.35	1.18	.89	.00	.30	.00	.66	2.1	.30
G-5	Hg	982	113	.00	.35	.37	1.33	.91	.00	.35	.00	.72	2.2	.35

*Number listed in this column designates type of Corning glass used for bulb or outer jacket

†With axis 30 deg from vertical





(Right) Ten sizes of Mazda fluorescent lamps which offer agriculture a cool daylight source of light • (Extreme right) This view shows the 1,000-w mercury lamp in its water jacket (left) and by itself (right)

number of starts per unit burning time. If lamp is burned continuously or with relatively few starts, longer than rated life may be obtained.

The useful life of the lamp is usually terminated either by fracture of the quartz bulb or failure to start. Although the pressure at the time of failure is well over half a ton per square inch, nothing of consequence happens. The internal volume of the lamp is exceedingly small, therefore, the stored energy is likewise small.

The three outstanding characteristics of this type of lamp — the brightness of the source, high actinic value, and coolness of light — have been utilized in searchlights, photochemical processes, photoengraving, photolithography and television studio lighting.

One might ask, "How can these characteristics of the lamp be used for agricultural purposes?" For one example, the cooling media instead of being water might be milk or some other fluid normally being used in the many fields of agriculture which would require activation or sterilization.

One advantage of this type of irradiation is that this lamp carries the fluid in a very thin film past the source of radiation, thus providing good utilization of energy. It is possible, of course, if not enough energy is imparted to the solution in this thin film, to recirculate the fluid past the lamp or provide an outer jacket which would allow a film of water or fluid to pass by the lamp in a layer thick enough to completely absorb the radiation. This outer jacket may be designed for placement on the outside of the conventional water-cooled jacket or made an integral part of the jacket. Another possibility of sterilizing or irradiating fluid is to place the lamp in the fluid to be sterilized or irradiated. This same fluid may be circulated through the lamp as a cooling media and then emptied into the main container or the fluid may be controlled so that the unirradiated portion flows adjacent to the lamp.

In the selection of material to be irradiated one must make sure that the ultraviolet radiation will not photochemically affect the fluid being irradiated. On the other hand, it might also be possible to take advantage of the sensitizers that are available and put them in the solution to sensitize the bacteria to radiation. For example, the water used for precooling vegetables by water spray may be passed through the lamp before it is sprayed on the vegetables. The lamp may even be built into the spray machine. It may be necessary to filter the solution and free it from UV absorbing particles.

There are many processes in which ultraviolet radiation is used as a catalytic agent. This lamp with an abundance of ultraviolet can readily be used for this purpose. In special cases filters may be used to screen out any radiation that may not be desirable.

Another interesting feature of the lamp is its therapeutic effect on animals. The lamp has an abundance of ultraviolet radiation, and it can readily be used for the irradiation of animals for production of vitamin D. Indeed, it is so potent in ultraviolet that the exposure would be a fraction of the time necessary to obtain equal results from the sunlamps normally used for this purpose. This suggests the possibility of having animals pass by the lamps as they enter and leave a building, thereby getting their irradiation.

TABLE 2. PER CENT OF OVERALL INPUT RADIATED IN VARIOUS SPECTRAL BANDS[1] BY 18-IN T8 MAZDA FLUORESCENT LAMPS

Type lamp	Overall input, w	Wavelengths in angstroms: 2800 to 3165	3165 to 3800	3800 to 5000	5000 to 6000	6000 to 7600	7600 to 14,000	Ultra-violet less than 3800	Visible 3800 to 7600
Blue	17.5	0.00	0.71	10.8	3.4	0.51	0.04	0.71	14.8
Green	17.5	0.05	0.22	1.79	9.8	0.19	0.02	0.27	11.8
Pink	17.5	0.02	0.11	1.00	1.86	5.2	0.09	0.13	8.0
Red	17.5	0.00	0.00	0.00	0.04	2.9	0.09	0.00	2.9
Gold	17.5	0.00	0.00	0.00	2.6	4.3	0.07	0.00	6.9
Daylight	17.5	0.03	0.23	4.8	4.4	3.2	0.08	0.26	12.4
White	17.5	0.02	0.16	2.4	4.8	4.4	0.11	0.18	11.7

TABLE 3. PER CENT OF INPUT RADIATED BY THE FILAMENT AND TRANSMITTED BY THE BULB[1] IN VARIOUS WAVELENGTH BANDS FOR MAZDA TUNGSTEN-FILAMENT LAMPS

Type lamp	Watts	Lumens per watt	Color temp (K)	Wavelengths in angstroms: Less than 3800	3800 to 5000	5000 to 6000	6000 to 7600	7600 to 14,000	Greater than 14,000	Visible 3800 to 7600	Infrared Greater than 7600	0 to 00
Regular	40	11.9	2780	0.04	0.62	1.68	5.1	33	28	7.4	61	68
Regular	100	15.5	2865	0.07	0.89	2.2	6.5	36	29	9.6	65	74
Regular	200	18.4	2940	0.10	1.10	2.6	7.8	39	30	11.6	69	81
Regular	500	20.3	2980	0.11	1.21	2.8	8.1	41	31	12.1	72	84
Regular	1000	20.7	3005	0.12	1.39	3.1	8.7	41	33	13.2	74	88
Bipost	1000	19.6	2995	0.10	1.19	2.8	8.0	38	31	12.0	68	80
Regular	1500	21.7	3055	0.11	1.46	3.2	8.8	42	33	13.5	75	88
CX	60	13.7	2825	0.06	0.73	1.87	5.7	31	29	8.3	60	68
CX	250	19.0	2950	0.11	1.21	2.8	7.9	40	29	11.9	70	82
CX	500	21.1	3015	0.13	1.30	3.0	8.1	41	31	12.3	72	84
Photoflood	1000	32	3360	0.29	2.5	4.6	10.3	40	31	17.4	71	88
Projection	900	26.5	3200	0.13	1.81	3.7	9.1	40	34	14.6	74	88
6.4V auto	15.8	16.7	2905	0.10	1.00	2.3	6.5	33	24	9.8	57	67

TABLE 4. PERCENTAGES OF SOLAR ENERGY FLUX, AT EARTH'S SURFACE (AT WASHINGTON, D.C.) IN VARIOUS WAVELENGTH BANDS[1]

Date	Type of day	Altitude of sun, deg	Wavelengths in angstroms: 0 to 3165	3165 to 3800	3800 to 5000	5000 to 6000	6000 to 7600	7600 to 14,000	Greater than 14,000	Less than 3800	3800 to 7600	7600 to 00
Feb. 19, 1903	Dry	30	0.01	0.90	11.5	12.9	20.8	41.8	12.1	0.91	45.2	53.9
May 14, 1907	Wet	30	0.01	1.01	12.7	14.3	22.5	39.2	10.3	1.02	49.5	49.5
May 14, 1907	Wet	57	0.06	2.58	14.2	15.2	21.5	36.1	10.3	2.64	50.9	46.4

[1]Spectral Distribution of Radiation from Lamps of Various Types, by B. T. Barnes, Dr. W. E. Forsythe, and W. J. Karash, General Electric Review, December 1939, vol. 42, no. 12, pp. 540-543 incl.

Heating Studies of an Outdoor Brooder

By John B. Greiner

IN OCTOBER 1939, the departments of agricultural engineering and poultry husbandry of the University of Georgia, in cooperation with the Bureau of Agricultural Chemistry and Engineering, U. S. Department of Agriculture, initiated a research project to investigate the heating of a small homemade, inexpensive outdoor brooder with electricity.

In the original experimental setup an attempt was made to include types of electric heating devices and applications which would be easy for the farmer to obtain and install as well as more elaborate units which would theoretically be more efficient.

Fourteen brooders were constructed, equipped with heating units and put into operation on the grounds of the poultry husbandry department at the University of Georgia late in December 1939. Of the fourteen brooders, twelve were heated electrically and two by kerosene oil lamps. Most of the electrically heated units were equipped with simple, inexpensive, bimetallic thermostats which were mounted so as to be adjustable from inside the brooder.

Six of the twelve electrically heated brooders were completely insulated, four had insulation on the top and on the sides, but not beneath the floor, and two were uninsulated. The insulation used was ½-in cane fiberboard nailed to the inside of the brooding compartment or to the under side of the floor. To protect it from picking by chicks and to make it moisture-resistant, this insulating board was given one coat of shellac and two coats of aluminum paint on the surfaces inside the brooding compartment.

It was felt that a bowl type radiant heater would be one of the simplest electric-heating devices which the farmer could obtain and install beneath the floor of the brooder in place of the oil lamp. Two 645-w heaters of this type were obtained and used in two brooders. One of these heaters was thermostatically controlled and the other had no control. The heaters cost 98c each, and were marked "Approved by the Underwriters Laboratories, Inc." Both brooders were insulated except for the floor.

In two other brooders 200-w mazda C lamps were used to replace the oil lamps. (One of these brooders was made from a plywood refrigerator box having the same approximate dimensions as the homemade brooding unit.) In each case a receptacle for the lamp was placed in the approximate center of the lower side of the floor. A receptacle for a 7½-w ruby attraction light was placed in the center of the upper side of the floor. During extremely cold weather an auxiliary 200-w lamp was placed in the attraction lamp receptacle in the brooding compartment. The cost of the lamps, sockets, wire, etc., for each unit was less than one dollar. Both brooders were partially insulated and neither heating unit was thermostatically controlled.

A method of heating using open-resistance coils beneath a rectangular, trough-shaped, metal reflector placed near the top of the brooding compartment was used in two brooders. One of these was completely insulated and the other was uninsulated. Both were equipped with thermostats. The same type of heating device was used in another brooder in which a motor-driven fan was used to blow warmed air onto the floor of the brooding compartment.

Commercial "package" heating units were used in two brooders, both of which were completely insulated. One of these heating units was equipped with a motor-driven fan for forced-air circulation and retailed for $17.50 completely equipped. The other unit had no fan and retailed for $4.75. Both of these heating units were very easily installed.

The heating element in two more of the brooders consisted of a nichrome wire resistance coil placed in a hollow compartment one inch deep formed by wooden strips separating the two parts of the double floor. One brooder was insulated whereas the other was uninsulated. Materials for constructing each of these heating units cost approximately $6.00.

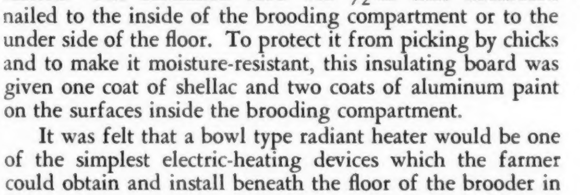
A nichrome wire resistance coil placed in a shrouded air inlet in the rear of the brooding compartment was used in one insulated brooder. Heat was thus added to the incoming fresh air and natural convection currents carried the warmed air into the brooding compartment.

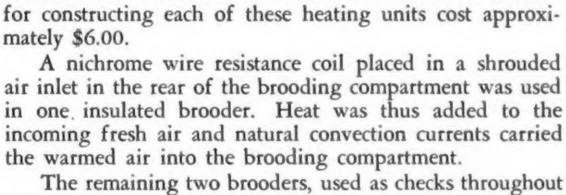
The remaining two brooders, used as checks throughout the tests, were heated with oil lamps. One was insulated except for the floor, and the other was uninsulated. During very cold weather it was necessary to use oil lamps to maintain temperatures comfortable to the chicks in the brooding compartment.

Throughout all the tests, temperatures in the brooding compartments of the brooders having thermostatically controlled heaters were regulated for comfort of the chicks as gauged by their behavior. Records of temperatures at eight points inside the brooding compartment of each brooder were taken daily for part of each of the first two series of tests, and twice daily for the duration of subsequent tests.

In the first series of tests week-old chicks were placed in the brooders on January 13, 1940, and brooded until March 1, a period of seven weeks. (In so far as possible chicks of equal size and vitality were selected for each unit in each of the tests which have been conducted.) The electric energy consumed by units varied from 120 kw-hr for

Paper presented before the Rural Electric Division at the annual meeting of the American Society of Agricultural Engineers at Knoxville, Tenn., June 1941. Author: Rural electrification research division, Bureau of Agricultural Chemistry and Engineering, U. S. Department of Agriculture.





(Left) A close-up of one of the outdoor homemade brooding units used in the Georgia heating studies • (Right) A view of the test layout of the homemade brooding units at the University of Georgia, described by Mr. Greiner in the accompanying paper

the fan-equipped commercial package unit to 553.8 kw-hr for the unit heated by the non-thermostatically controlled bowl type radiant heater. The two units equipped with fans for forced air circulation used less electricity than the units without fans.

The two units heated by coils located in the floor were next to the fan-equipped units in economy of electricity consumed. At the end of this series of tests it was decided to discard the non-thermostatically controlled bowl type radiant heater in favor of a heating unit combining nichrome wire heating coils in a hollow floor with forced circulation. This heating unit was made similar to the interfloor units previously mentioned, with the exception that a header or manifold was placed at the front of the brooding compartment and an air slot was left in the floor at the back. In operation, air was drawn from the upper part of the brooding compartment and blown down through a vertical tube into the header, across the heating coils up through an air passage at the rear of the brooding compartment, and was directed downward toward the level of the chicks.

The second series of tests in the 1940 season was conducted from March 16 to May 11, a period of eight weeks. Electric energy consumed per brooder in this period varied from 85.0 kw-hr for the fan-equipped unit having heating coils located below a trough-shaped reflector, to 262.0 kw-hr for the brooder having shrouded heating coils in an air passage in the rear of the brooding compartment. The non-fan-equipped and the fan-equipped commercial package units were second and third, respectively, in economy of electricity consumed.

MODIFICATION IN DESIGN AND ARRANGEMENT MADE NECESSARY FOR MORE EFFECTIVE PERFORMANCE

At the end of the first year's tests it became apparent that certain modifications in design and arrangement of the brooding unit proper and of the heating devices would likely prove beneficial. One of the most important changes made for the second year's tests was equipping all electrically heated brooders with wafer and snap-action, switch type, thermostats adjustable from outside the brooder. Because of their design and construction, these thermostats have given little or no trouble as compared with the bimetallic thermostats used in the first and second series of tests.

Considerable difficulty and inconvenience were experienced and much heat was lost when the lids of the units were raised to inspect the chicks or adjust the thermostat. For this reason, a glass observation window 3x19 in was installed in one side of each unit. These windows were protected with covers equipped with spring hinges.

Several of the heating units or methods of heating used in the 1940 season were discarded or changed prior to the start of the 1941 season. Among these were the bowl type radiant heaters and the heating coils in the shrouded air passage in the rear of the brooding compartment.

A heating assembly consisting of an 18-in strip heater mounted between two 20x36x$\frac{1}{8}$-in sheets of asbestos millboard was constructed to replace one of the discarded units. This assembly was about one inch thick and was placed on the upper side of the brooding compartment floor. Another assembly having a nichrome wire heating coil mounted on the underside of a circular piece of galvanized steel and equipped with a fan for forced draft was used to replace the other type of heater discarded after the 1940 tests.

The third series of tests was conducted from December 5, 1940, to January 31, 1941. Electric energy consumed per brooder in this period varied from 174.1 kw-hr for the non-fan-equipped commercial package unit to 340.5 kw-hr for each of two units in uninsulated brooders. One of these units had nichrome wire coils in a hollow floor; the other had similar heating coils located beneath a rectangular, trough-shaped reflector. The four units equipped with motor-driven fans in this series of tests were second, third, fourth, and fifth in economy of electricity consumed per brooder.

Throughout the tests conducted up to this time, there had been a great deal of trouble with excessively moist litter in almost all of the brooders. This necessitated cleaning the units as often as weekly and was a source of extra labor and unsanitary conditions. To avoid this difficulty, the sheet-metal floor was replaced with a wire screen. At the suggestion of Prof. Cooper of the poultry husbandry department, four brooding unit floors were made consisting of open frames of 1x2-in wood covered with $\frac{1}{2}$-in mesh hardware cloth. Sixty feet of soil-heating cable laid zigzag was fastened to the under side of each of two of these floors. A floor so equipped was placed on 1x2-in wooden cleats fastened $\frac{3}{8}$ in below the top edge of the bottom section of the brooder. The brooding compartment was placed around this floor and on top of the bottom section. This construction has served to prevent the entry of rain and cold air around the floor.

BROODERS HEATED WITH REFLECTOR DRYING LAMPS WERE MORE ECONOMICAL OF ELECTRICITY

The heating device used with each of the other two wooden-frame and hardware-cloth floor units consisted of one 250-w R4 reflector drying lamp. This type of lamp is recommended by the manufacturer for drying paints, etc., and has a relatively high heat output. The lamp was mounted above the doorway and was tilted to direct the rays at chick level toward the rear of the brooding compartment. One brooder of each pair having similar hardware-cloth floors but heated by the two different heating methods just described, was insulated; the other was uninsulated. Wood shavings were put in the bottom compartment of each of these four units to within about 3 in of the floor before the chicks were put in the units. These shavings which absorbed moisture from the droppings, materially reduced the air space to be heated and facilitated cleaning at the end of the tests.

The fourth series of tests was conducted from February 14 to April 11, 1941, a period of eight weeks. The brooders heated by 250-w reflector drying lamps were first and second in economy of electricity consumed per unit, and the non-fan-equipped commercial package unit was third in economy. Two of the fan-equipped units were fourth and fifth in economy.

Weather conditions during the first series of tests were extreme, the outside temperature reaching a low of 6 F. The lowest average temperature for any one day was 14 F, and the temperature for one four-day period did not exceed 32 F. Below freezing temperatures were recorded on 38 days during the series of tests. During the second, third, and fourth series of tests, the weather was not severe and temperatures of less than 32 F were recorded on three days in the second series, eighteen days in the third series, and eighteen days in the fourth series of tests.

Throughout these tests the brooders heated by kerosene oil lamps as checks have been more economical when costs of electricity and oil are compared. However, electricity offers convenience, cleanliness, and a reduction of labor requirements. The cost of several of the electrically heated units, which have been used in these tests, are within the farmer's ability to pay, and after further tests and modifications it is likely that the use of electricity to heat this type of brooder will become even more practical.

New Developments in Tractor Fuels and Lubricants

By C. N. Hinkle
MEMBER A.S.A.E.

WHEN THE first heavy tractors began to gain favor with the farmers, they were designed to burn kerosene, a straight-run fuel designed for lighting and heating purposes. Due to its low octane or antiknock properties, it is not the most suitable fuel for use in modern farm tractors although at the time the older tractors were designed, kerosene was the only fuel generally available on the farm. At that time gasoline was a drug on the market, and the big problem was to dispose of it. With the increased use of the automobile and motor truck, there soon developed a demand for gasoline, and within a relatively short time it became the principal motor fuel. This development led to a general distribution of both kerosene and gasoline and the design of the two-fuel tractors.

These stacks, pipes, and tanks reveal only part of the amazing complexity of a modern oil refinery. Unseen but equally important are the valves, dials, meters, and other equipment that control the processes by which crude oil is transformed not only into tractor fuels and lubricants, but also into many other petroleum products

Up until the time of the discovery of the "cracking" process, only about 10.7 per cent of the average crude oil could be converted to gasoline, but after it was discovered by Dr. W. M. Burton and Dr. R. E. Humphreys that, by applying temperature and pressure, the heavy molecules of oil could be "cracked" or broken up and reformed into the lighter molecules of gasoline, 45 per cent of the crude oil could be converted to gasoline. Today, even a larger percentage can easily be reached in case of need. This development, together with a large increase in the use of oil burners, has eliminated the heavier distillates as being "distress fuels." These heavier fuels are now in demand for burner and industrial use. They also have a definite value as a potential cracking stock, so the price difference between the heavier distillates and gasoline is much less today than a few years ago.

As compared to kerosene, the "cracked" distillates have a much higher octane or antiknock value (octane of 30+) and when properly treated to remove gums, sulfur, and other impurities, the "cracked" distillates are much more suitable fuels for use in internal-combustion engines. They have the further advantage of having a higher heat content per gallon than gasoline, and when used in a two-fuel tractor under favorable operating conditions, they will also provide more horsepower-hours per gallon. Tractor fuels or No. 1 distillates are generally somewhat lower than gasoline in price per gallon, due principally to transportation costs and taxes. Because of these advantages, some engineers feel that this is the most desirable fuel for the farmer to use and are specifically designing their tractors to take advantage of such fuels.

During the past few years there has been a large increase in the number of smaller tractors which are being used on the farms. All the modern tractors today are being designed to take advantage of the higher octane fuels available. This applies to both the high compression gasoline tractors and to the lower compression two-fuel tractors. The later model tractors are more efficient than the older models, as can be noted from reports of the Nebraska tractor tests and actual sales of fuel to modern tractors in field service. Rubber tires, starters, lights, and other conveniences are causing operators to demand fuels which will provide the maximum in convenience and engine flexibility. Even though such fuels may cost more per gallon, farmers are not as much concerned where their requirements per day are only 10 to 15 gal as compared to 30 to 50 gal required by the larger tractors used in the past. Not only are we witnessing a change to the smaller, more flexible tractors, but these tractors on many farms have entirely replaced the horse. The use of the tractor has been further increased by the introduction of new methods of farming and the development of new equipment.

Of the tractors on the farms today, 80 per cent are of the two-fuel type, that is, designed to burn either a heavy fuel or gasoline, but because of the poor condition of many of the older tractors and better flexibility and convenience of gasoline, we find that in the central states about 63 per cent of all the two-fuel tractors are being operated on gasoline.

Since the introduction of the high-compression, gasoline-burning tractors in 1936, the sales of this type tractor have increased very rapidly. Most tractor manufacturers have such models available and are selling them to the farmers in increasing numbers. With the number of tractors which have been converted to high-compression tractors in the field, the high-compression gasoline tractors now make up about 20 per cent of the tractors on farms. Most of these tractors have been designed to burn regular grade gasoline, but during the past two years there has been a general improvement in the octane value of most all gasolines so that the improved third grade gasoline of today has an octane value which is very near that of the previous regular grade fuel for which the first high-compression tractors were designed. Even though the regular grade gasoline is the preferred and recommended grade, many farmers have found that the

Paper presented before the Power and Machinery Division at the annual meeting of the American Society of Agricultural Engineers at Knoxville, Tenn., June 1941. Author: Tractor representative, sales technical service department, Standard Oil Co. (Ind.)

third grade gasoline will work very satisfactorily in their high-compression gasoline tractors for all but heavy and overload operation, so they are using this fuel. Where the farmer has a small tractor and other automotive equipment, such as a car or truck, regular grade gasoline is usually used.

The principal problem of the petroleum industry is that of supplying farmers with the various fuels they wish to use. The development and increased use of the smaller tractors and various state tax exemption laws have appreciably affected the demands of farmers during the past few years. Laws recently enacted in some states and the demand on the part of the farmer for fuels which will give better engine flexibility and convenience have encouraged the use of so-called volatile type tractor fuels.

Generally speaking, there are four classes or types of tractor fuels or distillates being sold in the central states. These range from the No. 1 tractor distillate as recommended by the A.S.A.E. Committee on Fuels, to a very volatile type distillate.

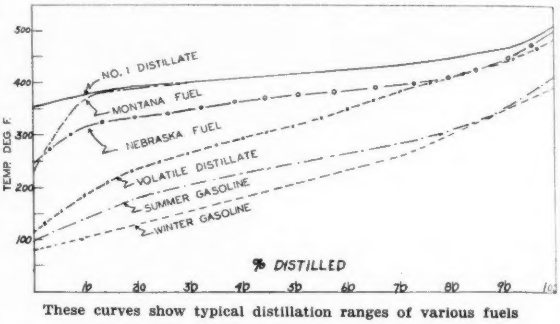
For maximum economy in two-fuel tractors, a high octane (30+) cracked, No. 1 tractor distillate, with a narrow distillation range (356-525) will fulfill this requirement most satisfactorily. Because of inadequate storage facilities, many of the smaller petroleum jobbers are selling a lower octane burner fuel as a tractor fuel. Such fuels are too low in octane value (0-20) to provide the most satisfactory engine performance.

When using a fuel of the No. 1 tractor distillate type, the operator must start his tractor on gasoline and allow it to warm up before switching to the heavier fuel, and proper operating temperature must be maintained thereafter. In cool weather and when pulling lighter loads, many operators find it rather difficult to maintain proper operating temperatures, especially where considerable idling is necessary, so for this type of service gasoline is usually used. The advantage, of course, claimed for the two-fuel tractor is that of being able to use gasoline and still take advantage of the lower cost fuels when pulling a heavy load.

The average two-fuel tractor will develop about the same number of horsepower-hours on a pound of gasoline as per pound of No. 1 tractor distillate or tractor fuel. As compared to gasoline, there is approximately 11 per cent more weight in a gallon of No. 1 tractor distillate, so that the average two-fuel tractor will run about 11 per cent more efficient on it than on gasoline. Another advantage of using a No. 1 tractor distillate is that of being able to purchase it tax exempt, without the bother of filing forms for tax refunds.

In some of the western states, such as Montana, a fuel similar to No. 1 tractor distillate, but with a decidedly lower first 10 per cent distillation, is commonly used.

Nebraska and some other states have laws which favor the sale of a more volatile type tractor fuel. The average fuels in these states have a distillation range of around 231-510 F. This has proved to be a very satisfactory fuel, but gasoline must be used for starting a cold engine. However, when the engine is warm, it can be started on this fuel. When starting a cold engine, it takes less time before the engine will handle the heavier fuel and in service operators obtain better engine flexibility on the more volatile fuel. Engine tests show that when outside temperatures are below 70 F, this fuel will give economies in two-fuel tractors nearly equal to that of No. 1 tractor distillate.

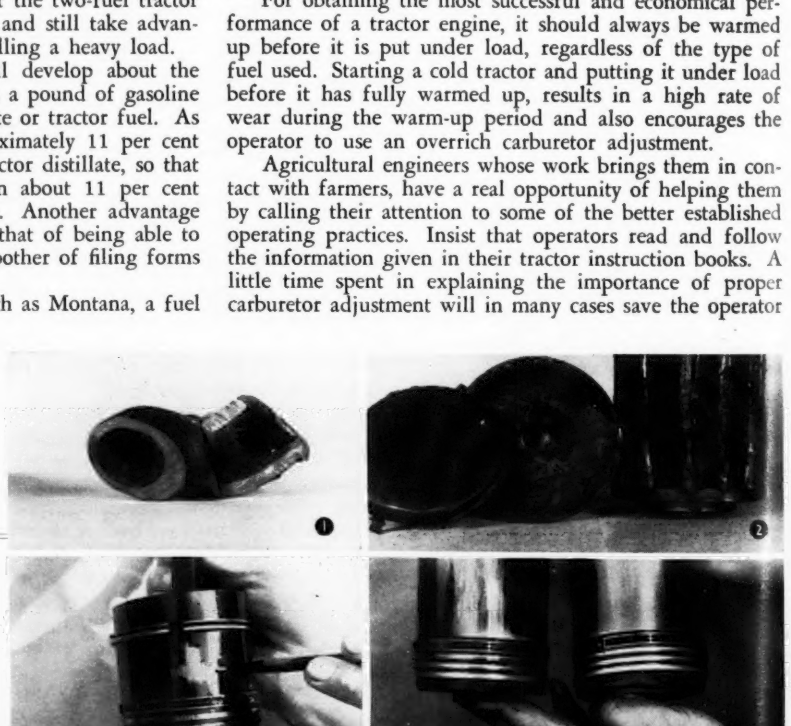


These curves show typical distillation ranges of various fuels

Recent laws enacted in some states have encouraged the use of very volatile distillates (110-510 F). The octane rating of the better fuels of this type is 40 or more. With sufficient use of the choke, a cold tractor engine can be satisfactorily started on fuels of this type at temperatures normally encountered when doing field work. Of course, if a tractor is being used for light work in cold weather, it is advisable to use gasoline. Most of the better brands of gasoline have balanced volatility and are seasonally controlled so they will provide the most satisfactory engine performance in cold weather.

For obtaining the most successful and economical performance of a tractor engine, it should always be warmed up before it is put under load, regardless of the type of fuel used. Starting a cold tractor and putting it under load before it has fully warmed up, results in a high rate of wear during the warm-up period and also encourages the operator to use an overrich carburetor adjustment.

Agricultural engineers whose work brings them in contact with farmers, have a real opportunity of helping them by calling their attention to some of the better established operating practices. Insist that operators read and follow the information given in their tractor instruction books. A little time spent in explaining the importance of proper carburetor adjustment will in many cases save the operator



(1) A coked intake manifold caused by using a fuel high in residue • (2) This picture shows an oil screen that became clogged due to improper maintenance • (3) A piston that has become covered with varnish • (4) This picture (piston on the right) shows how highly stable detergent oils keep piston rings clean

from $8.00 to $15.00 per year on his fuel bill and will also result in better performance and life of the tractor engine. It is not recommended that the tractor operator be encouraged to tinker with his carburetor, but it *should* be properly adjusted for the fuel being used. It has been found that many farmers are troubled with their tractors dying when idling, merely because the idling stop screw which controls the throttle valve has worn and allows the throttle valve to close completely. About a turn or so of the idling stop screw will correct this trouble.

Tractors are being used more and more each year during the cold winter months, so they must be given special care for this type of service. Water sludging is a common problem in this type of service. Few farmers realize that every time a gallon of fuel is burned, about a gallon of water is formed, and special care must be taken to maintain proper operating temperatures, or water will condense in the crankcase and form water sludge. To guard against this condition, the oil in the crankcase should be drained more frequently and the oil filter serviced regularly. There seems to be a general feeling among farmers that, inasmuch as they are not using their tractor for very heavy work during the winter, there is no need of changing the oil or servicing the filter. In many cases changing oil and servicing the oil filter is neglected to the point where the intake screen on the oil pump acts as a filter and soon becomes plugged. Conditions such as this result in burned-out bearings, stuck rings, burned valves, and sometimes scored cylinder walls. This trouble is becoming more common each year, but can be eliminated by maintaining better operating temperatures and more frequent oil drains. This condition cannot be corrected by a motor oil. However, the more stable, highly refined lubricants will be found to give greatest resistance to oil deterioration and water sludging.

NEW AND IMPROVED LUBRICANTS ARE MEETING THE NEW ENGINE LUBRICATION PROBLEMS

Engine lubrication problems have increased considerably during the past few years. This is due primarily to the use of higher output engines, lower oil consumption, smaller crankcase capacities, and localized heat conditions. Varnish is one of the most troublesome problems now confronting the oil industry, engine builders, and operators. This has been a major subject for discussion at many of the S.A.E. meetings for the past several years. Although we have known for some time that tractor engines are also subject to varnished conditions under certain types of operation, up to now this problem has not been very troublesome to the tractor operator, but with the trends in engine design along the same lines of that in the automotive industry, it is reasonable to expect that such troubles might become more common. However, the improvements being made in conventional lubricants and the general introduction of new lubricants, many of which are now on the market, with others to follow in the near future, will no doubt benefit tractor operators and prevent the varnish problem from becoming serious as far as the tractor owner is concerned.

For some time we have been finding the metal oil filters on some tractors quite heavily covered with varnish. This coating covers the fine wires which are spaced 0.003 in and usually causes the filter to fill up more rapidly. Where operators have become concerned with their filters filling up more rapidly, the rate of build-up can be lowered by flushing out the crankcase and cleaning the metal filter element. To clean the metal filter element, a solvent such as acetone or a strong solution of lye water must be used. When such solutions are used, the filter must be thoroughly flushed so as to remove any foreign material which might become loosened and remain in the filter. If such material is not removed, it may plug up an oil line and cause the bearings to burn out. It is believed that most of this varnish is formed by stopping a hot engine before the pistons have had a chance to cool down. The oil film between the hot piston and cylinder wall stews and varnishes. When the engine is again started, the varnish is scraped into the lubricating oil and is carried to the brass filter element. A new or rebuilt engine will often seize when stopped during heavy load operation without allowing the engine to run idle for a few minutes and give the hot pistons a chance to cool off.

Newly developed inhibitors and detergents have been found to be very beneficial in overcoming the varnish problem. The inhibitors are used to prevent oil oxidation, while the action of the detergent keeps the engine clean. Detergency may be explained as a cleaning action by which carbon and oil insoluble particles are prevented from accumulating in deposits by being kept in suspension. The detergent prevents the particles from gathering into large masses, and likewise prevents the adherence of soot and sludge to metal surfaces. Piston rings, oil passages, valves, oil screen, and other engine parts are kept free from deposits, thus permitting efficient engine operation. With oils of this type, the filters stay clean longer; however, the color of the oil cannot be used as an indication of oil condition. Oils of this type naturally become discolored very quickly. Extensive engine tests show that, contrary to what might be expected, the better types of detergent oils have an exceptionally low wear ratio.

RECENTLY DEVELOPED LABORATORY TEST TO HELP IN EVALUATING MOTOR OILS

As for determining the actual improvements which have been made in lubricating oils, it has been found that the long drawn out, costly process of engine tests is the most reliable method for making such determinations. A problem the engineers are facing today is that of standardizing engine tests. Of the laboratory tests, a recently developed oil oxidation stirring test looks very promising as a means of evaluating motor oils. It has been found that this oxidation test correlates much better with engine tests than some of the oxidation tests used in the past.

Motor oils and fuels, the same as tractors, have undergone many changes during the past years. Although the changes made in petroleum products are not as easily observed as the changes made in tractors, the better petroleum products of today are no more like the former than the modern tractor is like the first heavy plowing tractor. It seems reasonable to expect that we will see a continual improvement in petroleum products and tractors designed to take advantage of such products. The big problem, and the one which this society can do something about, is that of better educating the tractor operator so that he will be able to obtain maximum life and service from his equipment and full value from the petroleum products he is using.

Engineers as Leaders

IT IS self-imposed constructive hardship of hard work and of diligent forethought and action, which can build strength in democracy and provide the means of bringing a quicker end to war and its destructive hardships; which can influence the cost of war and reconstruction. In this, as workers and organizers, as men of disciplined originality and considered action, as providers of many of the tools of war and peace, engineers should be leaders.

Effect of Crops and Slopes on Rates of Run-off and Total Soil Loss

By James H. Lillard
JUNIOR MEMBER A.S.A.E.

THE EFFECTS of different crops and slopes on rates of run-off and total soil loss are important considerations in erosion and flood control planning. The intensity and duration of rainfall and inherent soil properties often act to complicate the relationship between these factors, and consequently affect their influence on the amount of erosion taking place under any set of conditions. The resulting effect of these forces must be evaluated by agricultural engineers and other soil conservationists in order to design erosion and flood control measures for either large drainage areas or for individual farms.

One of the more important investigations on rates of run-off from small plot areas under conditions of natural rainfall is the work of Knoblauch and Haynes[3]* on the effect of contour cultivation on run-off. They found that the peak flow of run-off from corn planted on the contour was lower for all rains studied than it was from corn planted and cultivated with the slope. Norton and Smith[4] in studying the effect of density of vegetation on rate of run-off of surface water concluded that dense vegetation on Marshall silt loam reduced the rate of run-off, as compared with that from wide-spaced vegetation, on unsaturated soil, except in cases where the land was freshly plowed. When the land under wide-spaced vegetation had been ridged by recent contour planting or cultivation and the soil was saturated at the beginning of a storm, they found that the maximum rate of run-off from a close growing crop may exceed that from wide-spaced vegetation, but in all cases the amount of soil removed per unit of run-off was less from areas on which dense vegetation was grown.

Borst and Woodburn[1] concluded from their rain simulator studies on the effect of slope on erosion and run-off that there was no significant difference in the rate of run-off from the different slopes and that the rate of run-off was essentially constant after equilibrium flow had been established.

The purpose of this report is to present a comparison of run-off rates and amounts from corn, wheat, and hay crops grown on five different slopes by means of hydrographs and maximum intensity curves. The results presented are for the specific conditions of cover and soil existing at the time of occurrence of four rains which fell at irregular intervals during the spring and summer of 1940. The records were obtained from a system of run-off plots at the Virginia Agricultural Experiment Station at Blacksburg, Va. The soil is classified as Dunmore silt loam which is rated as a very productive soil in this area. The soil profile of the plots shows an average of 5 to 7 in of A-horizon underlain with a relatively plastic clay.

In order to make these rates of run-off measurements, a system of fifteen 1/50-acre run-off plots were equipped with rate measuring flumes and automatic water-level recorders. These plots are located on slopes of 5, 10, 15, 20, and 25 per cent. Three plots lie adjacent to each other on each slope and are cropped to corn, wheat, and hay in a 3-yr rotation. The corn is planted and cultivated on the contour. The rows are 42 in apart with hills of 2 stalks each 36 in apart. No attempt was made to establish contour ridges through tillage operations; however, the slight amount of ridging which did result from each of the three cultivations was not sufficient to affect materially surface storage at the time of these storms. The wheat was drilled in hills 7 in apart on the contour. The clover and timothy seed were broadcast on the wheat and raked in. These operations were similar on all slopes.

This study is limited to the data from four rains which occurred during the months of May, June, July, and August. These rains were selected because they accounted for more than 85 per cent of the total seasonal soil loss from the plots, and they were fairly well distributed throughout the growing season thus providing records from the three crops under different conditions of soil tilth and cover.

Paper presented before the Soil and Water Conservation Division at the annual meeting of the American Society of Agricultural Engineers at Knoxville, Tenn., June 1941, and based on cooperative research by the Virginia Agricultural Experiment Station and the research division of the Soil Conservation Service, U. S. Department of Agriculture. Author: Assistant agricultural engineer, Virginia Agricultural Experiment Station

*Superscript figures refer to the bibliography appended to this paper.

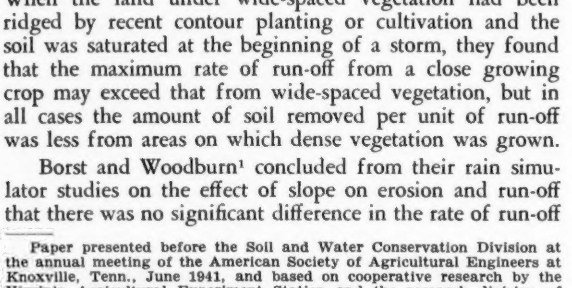
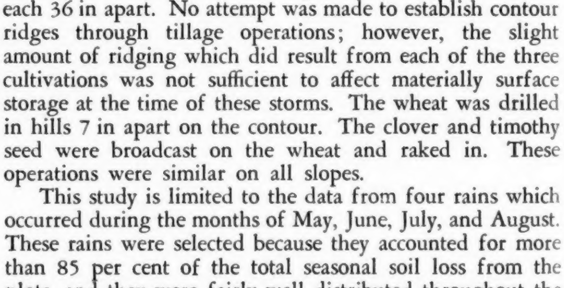
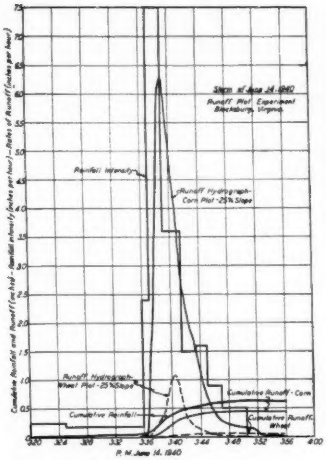


Fig. 1 (Left) Intensity pattern for the rainstorm of May 24, 1940, from the run-off and soil loss studies described in this paper



• Fig. 2 (Right) Curves representing rates of run-off for 1 to 30-min periods from all plots for the May 24 storm



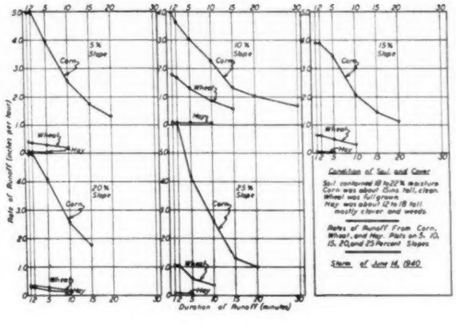


Fig. 3 (Left) Intensity pattern for the rainstorm of June 14, 1940 • Fig. 4 (Above) Curves representing rates of run-off for the June 14 storm

Rainfall and run-off graphs for corn, wheat, and hay on each slope were developed from the data for the four rains. In order to show the rainfall intensity patterns and to make comparisons of rates and durations of run-off from different crops and slopes one hydrograph for each storm is presented along with other graphs showing curves of maximum run-off rates for 1 to 30-min durations for each condition of cover and slope.

Results. The first rain came on May 24 following slow rains totaling 1.97 in on the preceding two days. The intensity pattern of this rain (Fig. 1) is not unusual for a summer thunderstorm. Soon after the rain began an average intensity of 4.65 in per hr was sustained for a 4-min interval. Twenty-eight minutes later a second intensity peak of 3-in per hr was sustained for a 1-min period, and 8 min later there came a third peak of 1.5 in per hr for a 2-min duration. The total rainfall was 1.09 in.

Hydrographs of the resulting run-offs from the corn and wheat plots on the 25 per cent slope illustrate how the run-off rates from the two types of cover responded to changes in rainfall intensity. As would be expected, the rate of run-off from corn was very sensitive to rainfall variations, thereby resulting in much higher short-time peak flows than was the case for wheat. The peak flow from the hay plots was very low in all cases and is not shown.

Curves representing maximum rates of run-off for 1 to 30-min periods from all plots are shown in Fig. 2 for the May 24 storm. At the time of this rain the surface soil contained about 25 per cent moisture. The corn had just come up and the wheat was beginning to head. The hay plots had a dense cover of clover and weeds 8 to 12 in tall. The soil of the corn plots was loose and permeable as a result of spring plowing and subsequent seedbed preparation. The effect of this soil condition was revealed in the relatively low rates of run-off from these plots which had no vegetative cover. The very low rates from the 10 and 15 per cent plots are attributed to variations in the soil on the different plots. These plot characteristics are evident throughout the data for all the storms. However, the record for this storm from the 10 per cent slope is the only case where wheat actually gave higher rates of run-off than corn. A few other cases were recorded where the cover influence was completely masked by these soil differences or other uncontrolled variables.

Rates of run-off from the hay plots, while included for comparisons, are practically negligible for all four storms. The run-off rates are likewise low for the wheat crop in most cases. The difference between the rates of run-off from the different crops tends to decrease toward the end of the run-off period. The data fail to reveal a definite relationship between slope and rates of run-off for any one of the three crops.

The second rain occurred on June 14. This was a thunderstorm having a maximum 2-min intensity of 7.5 in per hr followed by an additional $2\frac{1}{2}$-min period of 3.6 in per hr intensity (Fig. 3). The total rainfall was 0.64 in. At the time of this storm the soil contained about 20 per cent moisture; corn was about 15 in tall; wheat was mature; and vegetation on the hay plots was 12 to 18 in tall. This storm produced the highest rates of run-off recorded during this study, the highest peak flow being 6.30 in per hr from the corn plot on the 25 per cent slope.

The corn plots on the 10 and 15 per cent slopes yielded slightly lower 1 and 2-min rates of run-off than the other plots (Fig. 4). The effect of the soil condition was lessened by the high intensity of this storm. The high short-time rates of run-off from the corn plots indicate the ineffectiveness of wide-spaced vegetation in preventing excessive losses from storms of the high-intensity thunderstorm type. On the other hand, the run-off rates from wheat were relatively low from all plots. The run-off rates again fail to show a definite relationship to slope.

The storm of July 31 was included in order to study the run-off behavior of the different plots following a very high-intensity storm of extremely short duration (Fig. 5). This storm had a 1-min intensity of 7.80 in per hr which constituted the larger portion of the excessive rainfall. The total precipitation was 0.52 in. At the time of this rain the soil contained about 12 to 14 per cent moisture; corn

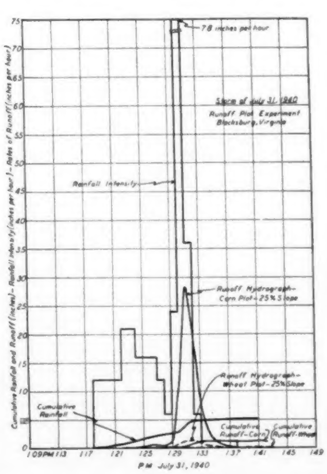
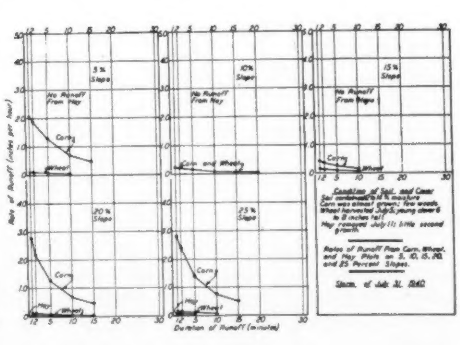
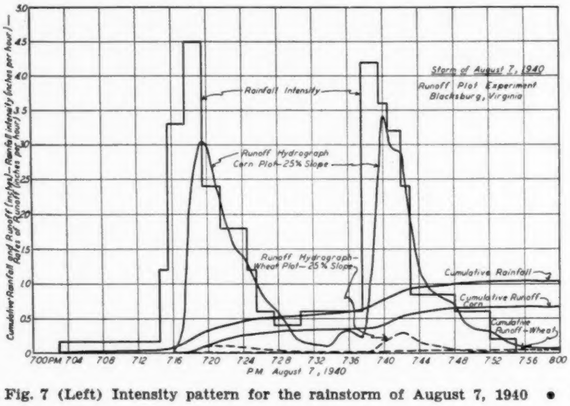


Fig. 5 (Left) Intensity pattern for the rainstorm of July 31, 1940 • Fig. 6 (Below) Curves representing rates of run-off for the July 31 storm





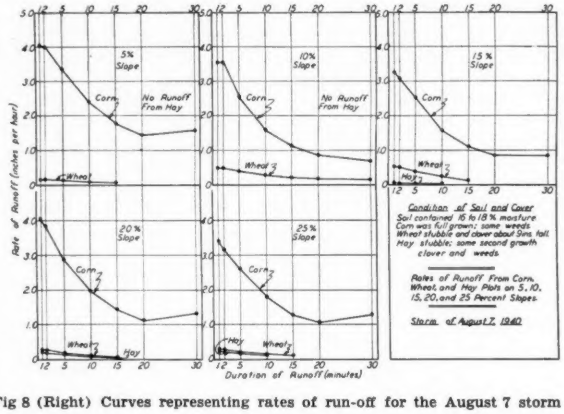


Fig. 7 (Left) Intensity pattern for the rainstorm of August 7, 1940 • Fig 8 (Right) Curves representing rates of run-off for the August 7 storm

was almost full grown; the wheat crop had been harvested on July 5, and a dense stand of young clover 6 to 8 in tall covered the wheat plots; the hay crop had been cut on July 11 but very little second growth had taken place.

The hydrograph of run-off from the 25 per cent slope indicates that the 1-min duration of high-intensity rainfall was not long enough to produce a high peak flow even from corn.

This storm again provided conditions under which soil or some other characteristics of the 10 per cent slope completely offset the crop effect on run-off rates and at the same time prevented appreciable amounts of run-off from both the 10 and 15 per cent slopes (Fig. 6). The short-time rates were higher from the corn plots on the other slopes but not nearly so high as those from the June 14 storm which had a 7.50 in per hr intensity for a 2-min period.

The August 7 storm consisted of two distinct periods of excessive rainfall (Fig. 7), having 2-min intensities of 4.5 and 4.2 in per hr, respectively. The duration of the storm was 52 min and the total rainfall was 1.05 in. The soil contained approximately 17 per cent moisture; the corn crop was full grown; a dense growth of young clover about 9 in tall covered the wheat plots; and the hay plots contained some second growth clover and weeds. The sustained intensity of this storm for periods from 1 to 30 min was slightly lower but somewhat comparable to the storm of May 24; however, the peak rates of run-off from the corn plots were twice as high. This difference was probably due to the more compact condition of the soil at the time of the August 7 storm.

The hydrograph of run-off from the plots on the 25 per cent slope revealed an impervious condition of the soil existed on the corn plots when this rain occurred. The young clover on the wheat plots gave very low rates of run-off.

The rates of run-off from the corn plots on all slopes were more nearly equal for this storm (Fig. 8). This similarity of run-off rates was probably due to the extremely compact condition of all the corn plot soils as they had not been cultivated for five weeks and had been subjected to several rains. These high rates of run-off reveal that even a full-grown corn crop is relatively ineffective in reducing rates of run-off.

Total soil and water losses from the corn plots resulting from each rain are summarized in Fig. 9. These losses varied greatly for the different storms and in some cases failed to maintain any definite relation to slope. Points representing average values for each slope are joined with broken lines. These data show that on slopes above 10 per cent the soil losses increased rapidly with increasing slope while there was no apparent slope effect on total run-off. The reasons for the extremely high soil loss from the corn plot on the 15 per cent slope for the June 14 storm and the high water losses from the 5 per cent slope for the August 7 storm are not known.

Discussion of Results. The run-off data from these storms (all of which fell well below Yarnell's[5] once-in-two-year frequency) point out the interacting effects of soil properties, slope, and vegetative cover on soil and water losses under different conditions of rainfall and soil tilth.

Since there is apparently a complex interaction of soil properties, crop effect, and rainfall on the character of run-off, it is doubtful whether the lower rates and amounts of run-off from the 10 and 15 per cent corn plots and the high values from the wheat plot on the 10 per cent slope can be explained by any one specific soil property. Data on mechanical composition, aggregation, organic matter content, and the dispersion ratio of these soils determined from samples taken at the beginning of the plot studies in 1937 fail to indicate the cause of the variations in rates of run-off, except that the soil on the 10 per cent slope contains more fine clay and has a higher volume-weight ratio in the A-horizon than those on the other slopes. This may account for the higher rates of run-off from the wheat on this slope. Conversely, the lower rates from corn on the 10 per cent slope may be due to an effect of cultivation increasing water penetration into the cultivated layer of this heavy clay.

Horton[2] states that, for storms of $\frac{1}{2}$-hr duration or less, the maximum run-off inten- *(Continued on page 406)*

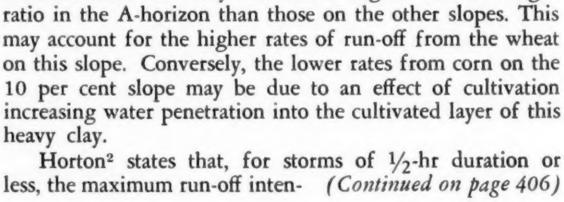


Fig. 9 A summary of the total soil and water losses from the corn plots resulting from each rain

The Electric Fence

By Charles F. Dalziel and James R. Burch

THIS PAPER is confined to a discussion of the hazard due to electric shock as it pertains to the electric fence and the results of extensive research made to determine a satisfactory and reasonably safe electric fence.

The term "electric fence", as used in this paper, means an electrified conductor, such as ordinary barbed wire, charged with sufficient electrical energy to be effective in controlling livestock. The fence controller is the device which controls and limits the amount of electrical energy permitted to the electric fence. There are three requirements of a satisfactory electric fence: (1) The fence must be effective, (2) it must be safe, and (3) the cost must be reasonable. It is realized that the cost of a safe controller must be within the reach of the average farmer; otherwise it may be difficult, if not impossible, to replace existing dangerous devices with scientifically designed units. Many of the fence controllers in use at the present time are hazardous; however, it is encouraging to note that but few fatalities have occurred on commercial units. Most of the electrocutions attributed to electric fences have occurred on units built by the farmer or the novice.

It should be stated at the outset that, because of the wide variation in the physical condition of individuals, it is impossible to design an electric fence or fence controller which will be safe for all humans. The press contains frequent accounts of fatalities ascribed to heart failure caused by overexcitement, intense emotion, fear, or shock (shock of injury and *not* electric shock). For such persons, it is possible that contact with an electric circuit which permits currents only slightly in excess of the threshold of sensation might adversely affect a diseased heart and result in fatality. This possibility must be recognized, and in spite of what may be done to develop a safe electric fence, an occasional death is to be expected due to casual contact involving electric currents known to be safe for normal individuals. Death in such cases should be considered due to shock and not to the primary effects of electric current[1*]. This hazard, although of considerable importance, is negligible in comparison with the danger to normal persons due to contact with many of the half million electric fences now in use throughout the country.

Coincident with the growth in popularity of electric fences, two safety codes were formulated in an effort to protect the public from undue electrical and fire hazards. The National Electric Safety Code[2] was adopted in April 1939, and the Underwriters' Laboratories Standard for Electric Fence Controllers[3] was published in September 1939. A few states, notably Wisconsin, Oregon, and Connecticut, have enacted legislation which in general provides for the enforcement of selected parts of these codes. Much controversy has been raised regarding differences between these two codes[4]; however, most of the differences are too small to be settled on the basis of existing experimental data. This controversy was unfortunate, because it has obscured the more important issue of enforcement. In many states, and especially where employed labor is not involved, enforcement of electric safety codes is left to local authorities. In rural areas enforcement has often proved difficult if not impossible. It is regrettable that there is no national body with both legislative and enforcement powers to protect the public from the purchase of dangerous home appliances and farm devices.

Sources of Information. Knowledge of the effect of lethal currents on man has been obtained, for the most part, from experiments on animals. The results of extensive experiments on animals have yielded much valuable information on the effect of electricity on the heart, respiratory organs, nervous system, and other tissues. The hearts of the larger animals respond in a manner similar to man's, and much data regarding the effects of electric current on this vital organ have been obtained from carefully conducted experiments on sheep, calves, pigs, and dogs. The hearts of some of the smaller animals, such as rats, guinea pigs, and rabbits, seem to be less seriously affected by electric currents, and these animals have been used to study damage to the muscles, bone, and nervous system. A second source of information regarding lethal currents comes from electrocution of criminals. However, legal electrocution has not added significant knowledge regarding minimum lethal currents. A third and most important source of information is a careful analysis of accidents where conditions were such that most of the important factors, such as the magnitude of the current, current pathway through the body, and shock duration are known within reasonable limits. It is generally agreed that the results from experimentation on animals may be applied to man from a qualitative standpoint, and research on animals is the best that can be done to determine accurately the effects of large currents. Experimental results are analyzed using statistical methods and estimates of probable limiting values for man are made with due regard to physiological similarities or differences.

The present investigation was started in 1936 to study the safety of electric insect traps. Little quantitative data were available, and experiments were made on men, animals, and insects to permit evaluation of safe and effective currents. With this as a background, the problem of the safety of electric fences was undertaken in the autumn of 1940. This investigation included additional experimentation on humans (the number now being in excess of 200), on cattle, and on both experimental and commercial electric fences. Also included was a study of returns from questionnaires sent to electric fence manufacturers and to laboratories having large impulse generators. In the interest of safety, the subjects used in these experiments were given a physical examination of the circulatory system and an electrocardiogram was taken. Only those over 21 years of age, in good physical condition, and without history of recent illness, and who had normal blood pressures and electrocardiograms were used. The age of most of the subjects ranged from 21 to 25 years, with about fifteen between the ages of 26 to 50 years. The tests were supervised by a physician from the medical school of the University of California, and great care was taken in the interest of safety. It was realized that the results on 60-cycle alternating current and direct current would have the greatest practical value, and therefore most of the tests were made using

Paper presented before the Rural Electric Division at the annual meeting of the American Society of Agricultural Engineers at Knoxville, Tenn., June 1941. Authors: Assistant professor of electrical engineering and senior student in electrical engineering, respectively, University of California, Berkeley.

*Superscript figures indicate references cited at the end of this paper.

60-cycle current, although some tests were made on frequencies from 5 to 10,000 cycles.

Types of Electric Fences. For purposes of this discussion, electric fences are classified as follows:

1 Non-interrupted
  - (a) Non-interrupted alternating current
  - (b) Non-interrupted direct current

2 Intermittent
  - (a) Interrupted alternating current
  - (b) Capacity discharge
  - (c) Inductive impulse

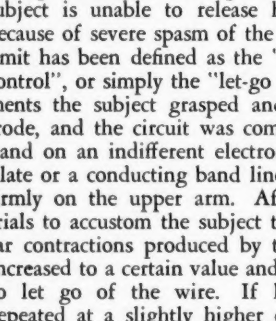
3 Single impulse.

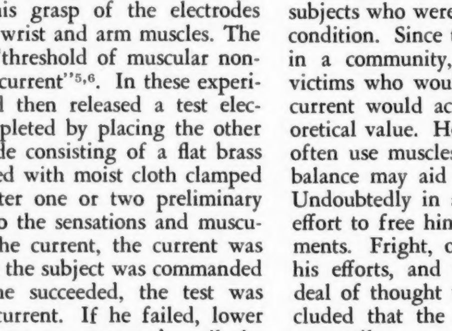
The Non-Interrupted Electric Fence. The safety of the non-interrupted electric fence, once a firm grasp has been made on the fence, depends upon the ability of the victim to release himself by using muscles directly affected by the current. The design of a safe electric fence controller must be based on current, as current and not voltage is the proper measure of shock intensity, sensation, and muscular reaction. The voltage of the circuit determines the amount of current; however, for a given current the voltage is of secondary importance in causing injury. This is particularly true with regard to electric fences in which the current must be definitely limited. The voltage of the fence should be sufficient to produce the required shocking current regardless of wide variations in ground, contact, and insulation leakage resistances.

For 60-cycle sine wave alternating currents, the threshold of sensation with electrodes held lightly in the hands is about 1.1 ma (milliamperes)[6]. If the current is gradually increased, the faint tingling sensations give way to pronounced sensations of warmth and muscular stimulation. As the current is further increased, muscular contractions predominate, and a point is finally reached where the subject is unable to release his grasp of the electrodes because of severe spasm of the wrist and arm muscles. The limit has been defined as the "threshold of muscular noncontrol", or simply the "let-go current"[5,6]. In these experiments the subject grasped and then released a test electrode, and the circuit was completed by placing the other hand on an indifferent electrode consisting of a flat brass plate or a conducting band lined with moist cloth clamped firmly on the upper arm. After one or two preliminary trials to accustom the subject to the sensations and muscular contractions produced by the current, the current was increased to a certain value and the subject was commanded to let go of the wire. If he succeeded, the test was repeated at a slightly higher current. If he failed, lower currents were used, and the test was repeated until the subject could no longer release the test electrode. The end point was checked by several trials, insufficient in number to cause fatigue, but sufficient to permit an accurate determination of the individual's let-go current. Tests were made with dry hands, hands moist from perspiration, and dripping wet from salt and weak acid solutions. The effect of electrode size was investigated, and electrodes consisting of a No. 7 copper wire and brass rods approximately ½, ¾, and 1 in in diameter were used. It was found that the surface condition of the hands, the size of electrodes, or the location of the indifferent electrode, had no appreciable effect on the let-go values.

Let-go tests were made on 125 subjects using the No. 7 copper wire electrode on commercial 60-cycle alternating current. The tests were conducted with the hands wet with a salt solution to secure uniform conditions and to reduce the sensation of burning due to high current densities at tender spots and at the instant of releasing the electrode. There was considerable variation in an individual's value on succeeding days, the trend usually being toward higher values. A definite cause for this variation was not found, but the method of analysis was believed to take this variation properly into account. The data were plotted on probability cross-section paper, from which it was apparent that the experimental results closely approached a normal distribution (Fig. 1). Statistical methods were employed to determine the expected response of an infinite group of the same age range and physical condition. The expected performance of 99½ per cent of the group was taken as a criterion of safety. The probable error of the 0.995 percentile was $\pm$ 0.8 ma. On this basis 99½ per cent of all men should be able to let go of 9.0, $\pm$ 0.8 ma or more current. It should be noted that the remaining ½ per cent of these men, or 50 in a group of 10,000, would not be able to release currents of this magnitude.

It should be repeated that these tests were made on subjects who were carefully selected with regard to physical condition. Since there are always a few subnormal persons in a community, it is expected that the percentage of victims who would not be able to let go of this value of current would actually be somewhat higher than the theoretical value. However, in accidental contact, a victim can often use muscles little affected by the current, or loss of balance may aid him to break away from the conductor. Undoubtedly in an emergency a victim would exert more effort to free himself than that stimulated in these experiments. Fright, on the other hand, might tend to nullify his efforts, and fatigue certainly would do so. A great deal of thought was given to this matter, and it was concluded that the criterion of safety, based on the 0.995 percentile, was conservative. It was therefore concluded





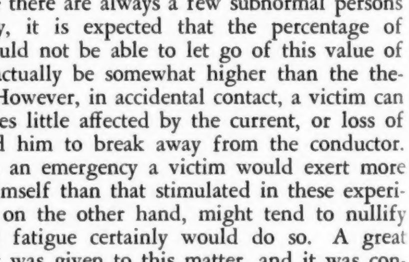


Fig. 1 (Left) Distribution curve showing results of let-go tests on 125 subjects using No. 7 copper wire electrode on commercial 60-cycle alternating current • Fig. 2 (Center) Safe let-go currents • Fig. 3 (Right) An experimental single impulse electric fence controller

that 8 ma should be a reasonably safe 60-cycle alternating current for man.

Reasonably safe currents for small children are undoubtedly lower than the value concluded safe for normal men. This conclusion is substantiated by the following: (1) The muscular reactions and effort required to let go of the test electrode in these experiments was considerable. As far as could be determined, the muscular strain for the various subjects was the same regardless of actual let-go values. (2) The less robust individuals and those having the smallest forearm circumferences had the lowest let-go values. (3) Tests were made on a well-developed boy 9 years of age. His thresholds of perception were close to the average obtained on men, but his 60-cycle, let-go current was only 7.6 ma. (4) Mr. Royce E. Johnson, director, electrical standards laboratory, University of Wisconsin, conducted a few similar tests and reports that a 60-cycle current of 7 ma was found to paralyze the grip of a 5-year-old boy. With the above in mind, it is believed that the safe 60-cycle alternating current for children should be taken as 50 per cent of the safe value for men, or 4 ma.

This matter is of importance because 7½ ma is believed to be the minimum current for effectively controlling livestock, and the regulations covering this type of fence specify a current limitation of 8 ma[2]. It is probable that this current is safe for man; however, in view of the above, currents of this magnitude may be hazardous to others, particularly small children and possibly women. The authors believe that this type of fence or fence controller, in which the exposed conductor is continuously energized from an alternating-current source as provided in the present regulations, is dangerous.

The safety of a non-interrupted, direct-current fence was studied and tests similar to the foregoing were performed using pure direct current. The threshold of sensation for electrodes held in the hands was found to be 5.2 ma[6]. When direct current was used instead of alternating current, the sensations produced were those of internal heating rather than severe contractions of the musculature. Sudden changes in current magnitude produced muscular contractions, and interruption of the circuit produced a very severe shock. Tests were made on 28 men, and in each case little difficulty was experienced in releasing the wire electrode. This difference in muscular reaction is in contrast to that produced by alternating current in which there was a very definite limit to the current that could be released. The test was started at a low current; several trials were made, and the current was increased until the shock produced at the instant of release of the test electrode became unbearable. A definite polarity effect was noticed, and the sensations were most intense when the test electrode was negative. The final values were termed release currents, and represent the limit of endurance rather than the let-go value. Direct-current release currents for 28 men were 61 ma minimum, 74 ma average, and 83 ma maximum[5]. Within the range covered in these experiments, physical endurance and the determination of the subject set the limit of the maximum release currents. Considering these factors, it appears conservative to conclude that the maximum safe direct current for man is at least 80 ma.

A reasonably safe direct current for children is believed to be 15 to 20 ma. The 9-year-old boy referred to above released direct currents up to 15 ma easily and without comment. Although currents of 20 to 40 ma have been used on men in experimental treatment of athlete's foot for periods of 20 to 40 min with small sensation and with little hazard to life, painless but rather deep burns were produced in tender flesh unless low-resistance surface contacts were maintained. A direct-current limitation of 15 ma is believed to be sufficient to control cattle, especially for conditions where excessive ground resistances are unlikely to be encountered, and a substantially higher current limit does not appear justified at this time. It was therefore concluded that a non-interrupted, direct-current fence with a current limitation of 15 ma should be reasonably safe. (It should be mentioned that this type of fence was omitted from both safety codes.)

TABLE 1. LET-GO CURRENT COMPARISON

SINE-WAVE AND FULL-WAVE RECTIFIER

No. 7 copper wire electrode

Subject No.	Sine wave rms ma	Hand positive Full-wave rectifier avg ma
82	12.2	15.0
129	13.5	20.2
128	13.5	16.0
130	14.6	22.1
132	16.1	19.8
45	16.2	18.5
123	16.2	18.5
131	16.8	19.0
125	17.3	23.4
124	18.2	21.5
122	19.8	21.0
109	20.0	26.4
37	20.9	26.4
105	23.0	27.5
Mean	17.0	21.1

FULL-WAVE RECTIFIER CURRENT ANALYSIS

Hand electrode positive

Probable mean current for all men $= 21.1 \times \frac{15.6}{17.0} = 19.4$ avg ma

Probable safe current for all men $= 19.4 \times \frac{8}{15.6} = 9.9$ avg ma

Safe current $= 0.5 \times 9.9 = 5.0$ avg ma

The possibility of using rectified current was investigated in let-go tests with a full-wave and a half-wave rectifier. The data are given in Tables 1 and 2. Sixty-cycle sine-wave tests were made at the same time to serve as a control, and probable safe currents for men were determined by correcting the mean values of the group to the mean of the 60-cycle, let-go current test. The result was multiplied by 8/15.6 to obtain the 0.995 percentile value.

TABLE 2. LET-GO CURRENT COMPARISON

SINE-WAVE AND HALF-WAVE RECTIFIER

No. 7 copper wire electrode

Subject No.	Sine wave rms ma	Hand positive Full-wave rectifier avg ma
77	14.4	7.0
132	15.6	9.1
129	16.9	8.6
93	17.1	10.1
125	17.3	9.1
124	17.3	9.5
126	17.8	8.5
130	18.5	8.9
45	18.5	6.7
37	20.9	9.8
21.	25.1	10.0
Mean	18.1	8.84

HALF-WAVE RECTIFIER CURRENT ANALYSIS

Hand electrode positive

Probable mean current for all men $= 8.84 \times \frac{15.6}{18.1} = 7.6$ avg ma

Probable safe current for all men $= 7.6 \times \frac{8}{15.6} = 3.9$ avg ma

Safe current $= 0 5 \times 3.9 = 2.0$ avg ma

This procedure was justified on the assumption that a normal distribution similar to the 60-cycle test would have been obtained had the entire group been used. The safe current for children was estimated by multiplying this value by 0.50. The analysis at the bottom of the tables illustrates the details of computation. Similar tests were made to determine the safe let-go current for composite waves containing alternating current superimposed on direct current.

Typical test data are given in Table 3. It may be of interest to call attention to the effect of polarity on let-go values, which is apparent from inspection of the tabulated data. Lowest values were obtained when the test electrode was negative, and these were plotted to permit determination of safe let-go currents for a composite wave (Fig. 2). The safe let-go current curve was obtained by multiplying the mean values for men by 0.50 x 8.0/15.6 as discussed above. The results clearly indicate the necessity for filtering rectified currents to obtain a reasonably low ripple content.

TABLE 3. LET-GO CURRENT COMPARISON

SINE-WAVE AND 50 PER CENT OFFSET WAVE

No. 7 copper wire electrode

Subject No.	Sine wave rms ma	Hand positive Components a-c rms ma	Hand positive Components d-c avg ma	Hand negative Components a-c rms ma	Hand negative Components d-c avg ma
129	15.1	8.4	25.2	7.8	23.4
82	16.2	8.3	23.3	8.1	22.4
135	16.7	8.6		8.6	
93	17.2	7.9	24.2	6.0	18.5
123	17.5	7.2	20.5	6.3	18.0
130	17.6	9.3		7.8	
132	18.3	8.6	26.3	6.8	21.2
125	19.3	7.7	22.5	7.1	20.7
134	19.8	9.5	26.1	9.8	27.5
124	21.5	9.2		8.3	
Mean	17.9	8.5	24.0	7.7	21.7

50 PER CENT OFFSET WAVE ANALYSIS

	Hand positive	Hand negative
Probable mean a-c component for all men	$= \frac{8.5 \times 15.6}{17.9} = 7.4$ rms ma	$\frac{7.7 \times 15.6}{17.9} = 6.7$ rms ma
Probable mean d-c component for all men	$= \frac{24.0 \times 15.6}{17.9} = 21.0$ avg ma	$\frac{21.7 \times 15.6}{17.9} = 18.9$ avg ma
Safe a-c component	$= 7.4 \times \frac{4}{15.6} = 1.9$ rms ma	$6.7 \times \frac{4}{15.6} = 1.7$ rms ma
Safe d-c component	$= 21.0 \times \frac{4}{15.6} = 5.4$ avg ma	$18.9 \times \frac{4}{15.6} = 4.8$ avg ma

The Intermittent Electric Fence. Intermittent types of electric fences were developed to utilize higher current outputs in the attempt to increase effectiveness and also to permit the use of both direct and alternating-current sources of energy. In these types, the fence controller impresses a short shock followed by an off-period, during which interval it is assumed the victim will release himself. The intermittent alternating-current fence controller is a device which transforms power usually from an ordinary lighting circuit, and applies a shock to the fence at intervals of approximately one second. In the capacity discharge type, the discharge of a condenser is used to furnish the shock impulse. The inductive impulse fence controller operates on the induction coil principle, and this type is usually energized from batteries. The regulations for impulse fence controllers provide for a maximum impulse current limitation of 300 to 500 ma, a quantity limitation of 3 to 4 mc (millicoulombs), and an off-period of at least 0.75 sec.

The current output for these types of fences must be limited so as to prevent ventricular fibrillation and inhibition of respiration, but to date there are insufficient experimental data on which to base quantitative conclusions. Many hundreds of thousands of these fences are in use, and on the basis of field experience one may conclude that the regulations given in the present safety codes are probably satisfactory from this standpoint. It is generally conceded that the safety of the intermittent fence depends upon the ability of a victim to release his grasp from the fence during the off-period. The practicability of accomplishing this fundamental requirement must be carefully scrutinized. In addition, it would appear that safety to life depends entirely upon the unfailing operation of complicated mechanisms (some of which have moving parts) not for a year, not for life, but forever. Assuming that ultimate failure occurred, what assurance could there be that the fence controller would be junked or returned to the factory for repairs? Is it not more likely that the farmer or the novice would attempt repairs, together with possible improvements, without regard to safety?

Half a dozen subjects took the output from an alternating-current fence controller which delivered 25 ma output, 0.10 second shock duration, and 1.0 second off period, for ten shocks. The unanimous opinion of the group was that in accidental contact, if a victim was unable to release himself, the effect of the repeated shocks would be torture —a 20th century adaptation of medieval practices. It is not impossible that an animal or human might get caught, or for other reasons be unable to free himself from contact with such a fence. During the intermittent fence tests none of the subjects had difficulty in releasing the test electrode during the off-period between successive shocks. However, it is known that during severe electrical shocks there is a time delay before one can use the affected muscles, and after accidents entire extremities of the body may be paralyzed for extended periods, sometimes lasting hours after interruption of the current. The time lag of muscular paralysis for currents of the magnitudes approved by the safety codes, particularly for small children, is not known. Also, there is a possibility that a very young child, after having established a firm grasp on the fence, might suffer such surprise shock, fear, and muscular contractions, that he might become panic-stricken and cry for help instead of making a determined effort to free himself. For these reasons the authors believe that the intermittent fence, although possibly safe from a strictly electrical viewpoint, should be considered inhumane.

SINGLE IMPULSE FENCE RESULT OF ATTEMPT TO DEVELOP A SAFE FENCE

The Single Impulse Electric Fence. The single impulse electric fence resulted from a study of existing electric fences in the attempt to develop a fence that would be reasonably safe and yet effective for wide variations in ground and contact resistances, and without the disadvantages and hazards discussed in the preceding paragraphs. In the type proposed here, the fence is energized from a controller which maintains a high direct-current potential on the conductor and delivers one single impulse shock instantly on firm contact. Animals receive a shock on each contact. If a person grasps the fence, the impulse rapidly decreases to a safe sustained direct current which may be easily released as soon as recovery from the sudden surprise permits doing so. Extensive tests were made to verify the safety, effectiveness, and to determine a satisfactory design of an experimental model. The fence is believed to be reasonably safe on the basis of the technical criteria previously mentioned and from the results of experiments made on men and animals, including tests on cows, calves, sheep, lambs, and hogs. The fence proved effective for wide variations of contact and ground resistances, and also for a considerable range of insulation leakage resistance. This device should possess the advantage claimed by certain manufacturers that direct current has weed-killing powers which aid in reducing leakage currents. Advantage was also taken of the polarity effects, and the fence was connected to the negative side of the circuit to give the greatest sensation for a given current.

The voltage of an electric fence should be sufficiently high so that large variations in ground and contact resistances produce a relatively small effect on the magnitude of

the shock current. On the other hand, very high voltages are likely to cause excessive leakage and insulation problems. Due to the limited current output, this might result in a low fence voltage and unsatisfactory operation. The results from a questionnaire sent to all known electric fence manufacturers were studied, and, with the above in mind, it was concluded that a direct-current voltage of 1750 v should be satisfactory.

An experimental single impulse fence controller was constructed as shown in Fig. 3. The controller consists essentially of two parts, a high voltage rectifier and a resistance-condenser filter. The rectifier presented no special problem other than selection of suitable vacuum tubes. Type 879 tubes were used and are believed satisfactory because of low filament power consumption and high voltage rating. The condenser performs three functions: (1) It provides a source of energy for the impulse shock, (2) as the impulse decays, filtering action takes place and the ripple content of the sustained output current is reduced to a safe value, and (3) in the event a short circuit occurs in either the transformer or vacuum tubes, the condenser acts as a low impedence shunt and limits the output current to a safe value. It was found that when there was considerable resistance in series with the condenser, sensations were almost entirely dependent upon the peak impulse current and the discharge from condensers of 0.5 to 2.0 μf (microfarads) produced undetectable differences in sensation and muscular reaction. It was therefore concluded that the size of condenser was not particularly important from this viewpoint. The capacity of the condenser was determined largely by the allowable ripple, and a 2000-v, 2-μf condenser was believed satisfactory. The charge in this condenser at 1750 v has a theoretical value of 3.5 mc, and is believed safe for reasons to be discussed later. The results of the questionnaire also indicated that one of the chief weaknesses of a condenser type controller was the possibility of condenser failure due to lightning or electrostatic disturbances. A modern 2000-v pyranol condenser is designed for an impulse strength of 5000-v peak value for a 10x40-microsecond wave. It is believed that a small lightning arrester set for 3000 v should protect the condenser and eliminate this difficulty.

Experiments were made to determine the required impulse current. Tests were conducted in the corrals of the division of veterinary science of the University on 12 cows, 15 calves, including a calf but two days old, and on a dozen sheep. A variable external resistor was connected in series with the fence terminals to simulate high ground resistance and to study impulse current requirements. The controller was found to be effective with external resistances as high as 80,000 ohms. An impulse current of 100 ma was found to be both very unpleasant and ample to restrain cattle, and in the interest of safety it was decided to limit the maximum impulse current at this value. (NOTE: This current limitation is considerably below that permitted in the safety codes.) As previously mentioned, the sustained current should be as high as consistent with safety to maintain sufficient voltage during times of excessive leakage. With this in mind, the sustained current was limited to a maximum of 15 ma.

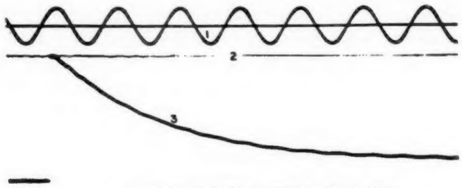


FIG. 4.--SINGLE IMPULSE ELECTRIC FENCE CONTROLLER TEST
Full Wave Rectifier Connection
1. 60 cycle timing wave r = 17000 Ohms Impulse Current = 100 M.A.
2. 100 M.A. Calibration R = 53300 Ohms Sustained Current = 15 M.A.
3. Impulse Current C = 2 mfd. External Resistance = 500 Ohms

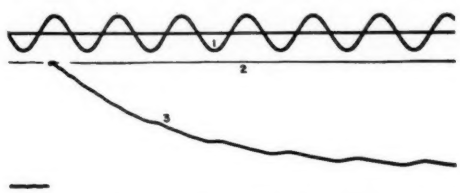


FIG. 5.--SINGLE IMPULSE ELECTRIC FENCE CONTROLLER TEST
2. V.T. Half Wave Rectifier Connection
1. 60 cycle timing wave r = 17000 Ohms Impulse Current = 100 M.A.
2. 100 M.A. Calibration R = 26700 Ohms Sustained Current = 15 M.A.
3. Impulse Current C = 2 mfd. External Resistance = 500 Ohms

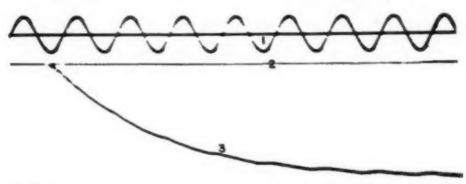


FIG. 6.--SINGLE IMPULSE ELECTRIC FENCE CONTROLLER TEST
1. V.T. Half Wave Rectifier Connection
1. 60 cycle timing wave r = 17000 Ohms Impulse Current = 100 M.A.
2. 100 M.A. Calibration R = 64000 Ohms Sustained Current = 7½ M.A.
3. Impulse Current C = 2 mfd. External Resistance = 500 Ohms

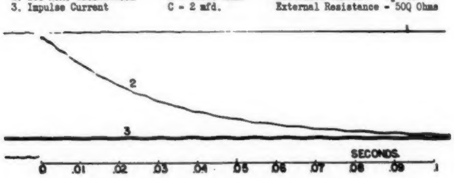
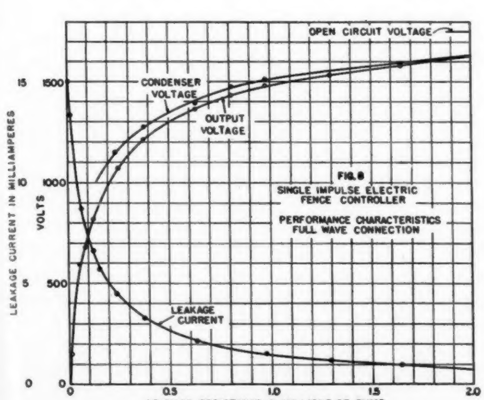


FIG. 7.--SINGLE IMPULSE ELECTRIC FENCE CONTROLLER TEST
Full Wave Rectifier Connection
1. 100 M.A. Calibration r = 17000 Ohms External Resistance = 500 Ohms and
2. Impulse Current R = 53300 Ohms Subject 93. Feet in 1 inch of salt
3. Sustained Current C = 2 mfd. water, hand in salt water to wrist.



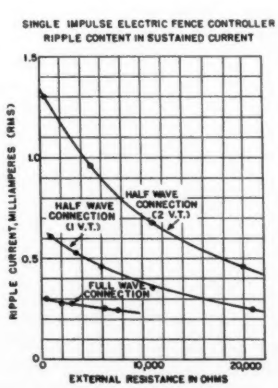


FIG. 9

Fig. 8 Regulation curves for full-wave connection of single impulse electric fence controller • Fig. 9 Ripple content in sustained current

Performance characteristics of the experimental controller were investigated for three positions of the switch shown in Fig. 3. Typical oscillograms and technical data are given in Figs. 4, 5, and 6. Fig. 7 is an oscillogram of the current received by one of the authors for the full-wave connection. For all cases the resistance of the oscillograph circuit was adjusted to 500 ohms to conform to the standard test conditions specified in the safety codes. It was found that the point on the applied voltage wave at the instant the circuit was completed produced a negligible effect on the current wave shape. Regulation curves for the full-wave connection are shown in Fig. 8. With the exception of ripple content in the sustained current, the operating characteristics for the full-wave connection and the half-wave controller using two vacuum tubes in parallel were nearly identical. The performance of the one-tube, half-wave rectifier controller (obtained by placing the switch of Fig. 3 in the middle position) was similar, except that the sustained current was limited to 7.5 ma so as not to exceed the tube rating. The differences in ripple content are shown clearly in Fig. 9. For each connection the ripple and sustained currents corresponding to the standard test load of 500 ohms were referred to Fig. 3, from which it was concluded that the full-wave connection and the one-tube, half-wave connection were satisfactory from a safety standpoint, and the two-tube half-wave connection was condemned.

The following comments pertain to safety:

1 The filaments of two-tube rectifier controllers should be connected in series to prevent operation should one tube be removed or filament failure occur.

2 With the controller connected for one-tube, half-wave rectifier operation, a connection was applied between the filament circuit and the plate to simulate an internal short circuit in the tube, the result of attempted emergency repairing, or tampering. Under this condition the controller output current consisted of a pure alternating current of 1.8 ma rms. Approximately twice this value was obtained for the two-tube, half-wave rectifier connection.

3 A similar test was made for the full-wave connection and a composite output current of 3.0 ma rms alternating current and 1.8 ma direct current was obtained. It may be of interest to mention that this caused the other tube to break down and the short circuit blew the fuses in the power supply.

4 Tests were made to investigate the fire hazard, as the possibility of igniting combustible material which might be in the vicinity of possible arcs between the fence and grounded objects must be recognized. Two straight pins were connected to the output terminals of the controller. The gap between the pin points arced over when reduced to approximately 1/32 in. It was found possible to maintain and draw out the arc to about 3/32 in when the full-wave connection was used. The vigor of the arc was materially less with the one-tube controller, and it was not possible to maintain an arc much longer than 1/64 in. Although the fire hazard for the full-wave connection might be considered unsatisfactory, it is believed that the one-tube rectifier controller should be satisfactory in this respect.

These tests demonstrate that this type of controller should be reasonably safe; failure in the field should make the unit inoperative rather than increase the hazard. It is the author's opinion that the principle of the single impulse electric fence controller is fundamentally sound. Rigorous field tests to confirm this conclusion appear warranted.

Body and Contact Resistance. Tests were made to determine reasonable minimum body and contact resistances likely to result during contact with an electric fence. It was thought that the high open circuit voltage of the fence controller might puncture the outer layers of the skin and result in considerably lower resistances than those observed in the let-go tests[5]. This effect was investigated by comparing body and contact resistance for gradually increasing direct-current voltages with the value obtained a moment later by suddenly grasping the output of the single impulse fence controller. In order to obtain comparable results the resistance was computed from current and voltage readings for steady currents of 15 ma. Body contacts were the same for both cases and consisted of standing in a metal container with both feet immersed 3/4 in in salt water, and grasping the No. 7 copper wire electrode with hands dripping wet with the same solution. The results of this test are given in Table 4. Although some reduction in resistance was noted, it was apparent that the output of the controller was not sufficient to cause material breakdown of the skin.

TABLE 4. BODY RESISTANCE TESTS

Contacts — hand grasping No. 7 copper wire and both feet standing in metal pan immersed in 3/4 in salt water

Subject No.	Steady state Resistance in ohms: Right hand to both feet	Steady state Resistance in ohms: Left hand to both feet	Impulse Resistance in ohms (after 100-ma impulse): Right hand to both feet	Impulse Resistance in ohms (after 100-ma impulse): Left hand to both feet
128	1260	1490	1190	1510
124	1630	1500	1390	1260
125	1450	1600	1410	1490
82	1370	1640	1300	1400
132	1250	1275	1200	1160
104	1480	1500	1710	1440
129	1460	1230	1135	1250
93	2150	1970	1730	1820
137	1650		1170	
Minimum resistance	1230 ohms		1135 ohms	

Tests were also made to determine body resistance in which skin and contact resistance was minimized by immersing the arm to the elbow and standing in 10 in of salt water. This was done to simulate extreme conditions where the skin had been burned through to the flesh or where the victim was standing in water such as in an irrigation ditch or a sump. Preliminary results on alternating current and direct current indicate the range of body resistance to be 400 to 600 ohms.

Hazard Due to Impulse Currents. The hazard due to the charge on the fence is important because the shock increases with the amount of charge on the fence, and the latter increases with fence length. The charge on the fence is equal to the product of voltage and capacitance. Assuming uniform conditions, capacitance and leakage current are proportional to the length of fence, but since the leakage current reduces the voltage, the charge will not increase in direct proportion to fence length. It is also to be expected that, as the length and therefore leakage is increased, the voltage will gradually decrease and a point will finally be reached where the fence will no longer be effective. These factors should provide an inherent degree of safety. Since leakage may be negligible when the fence is new and during fair weather conditions, consideration was given to the most hazardous condition — a long fence having no leakage.

Little quantitative information was available regarding the hazard due to impulse currents. Messrs. Kouwenhoven and Langworthy[7] experimented on rats with a surge generator using a 1/4x4-microsecond wave with an output current of 100 amp maximum crest at 200,000 v. Thirty-five rats were used in the experiments. They were placed in various positions so that the discharge passed through different parts of their bodies. Among other findings these authori-

ties concluded that "damage to the organism is greater, the greater the proportion of vital organs lying in the current path. When the surge passed from the head to the tail, none of the animals breathed. As the brain and nerve centers were eliminated from the path by moving the electrode down the back, the chances of recovery became greater". Considering the magnitude of the generator output and the fact that 17 out of the 35 rats were not killed, leads to the conclusion that impulse currents are not particularly hazardous to life.

A request for accident experience on impulse currents was sent to laboratories having large lightning generators with the thought that a comparative study might reveal dangerous current and charge limits for man. It was gratifying to note that no fatalities have occurred on this type of equipment, although a number of serious accidents were reported on associated power frequency apparatus. Several accidents from charged condensers were mentioned, but, like most accidents, insufficient information was available to permit definite conclusions. The details of three accidents were fairly well known and they are of such unusual interest that excerpts are given here:

Case 1. A man came in contact with a 3-μf condenser charged to 3000 v while working on a cathode ray oscillograph. Resistors in the circuit totaled about 50,000 ohms. The points of contact were a finger and the soles of the feet. Very small burned spots were visible on his finger, but there was no mark on the feet. The shock was painful only for its very short duration, and it caused him to perspire for a few minutes. His heart action was checked within half an hour and found normal, and there was no other reaction or after-effect.

Case 2. A man was passing a bank of high voltage condensers which had been discharged. There were 15 condensers of 0.33 μf, each connected in series, and the residual charge had sufficient voltage to jump a gap of 6 in (estimated 125 kv) to his hand; the other contact was both feet. This spark appeared to be unusually red, and after a few minutes a Lichtenberg figure appeared on his wrist. The figure was blue and the wrist was numb. Both the numbness and the Lichtenberg figure remained only for a few minutes. The shock was most painful in the feet, but after a few minutes there were no further effects or reactions.

Case 3. An accident occurred to the operator of a surge generator which had a total capacity of 0.2 μf and was connected for 500 kv. The operator was adjusting a sphere gap when the generator accidentally tripped. The last gap on the generator received a voltage of 500 kv, and the case of the last bank of condensers received a voltage of 450 kv. When the generator tripped, flashover took place from the case of the last bank to the center of the operator's abdomen and down through his legs to the floor. The intense muscular contraction threw his right arm against the last condenser bank and resulted in a very heavy shock into his right arm. The discharge entered his stomach through a belt buckle and left a small burned spot about the size of a dime. The discharge apparently flashed over his feet, since it blew a large hole in his left shoe and also opened up the seams on the right shoe. Apparently there was a very heavy discharge through his heels, and a large number of small but very deep holes were found in the operator's heels, which, incidentally, caused no discomfort. The discharge caused intense muscular reaction, and the operator lost the use of his legs temporarily and was unable to hold himself up, but did not lose complete consciousness. The discharge caused partial paralysis of the legs, and although he could make his toes move, the only way he could tell they were moving was by looking at them, since he had no sense of feeling whatever. This same condition occurred with the right arm, although it cleared up in about 2 hr. The legs were paralyzed for about 8 hr. The discharge left a Lichtenberg figure on the operator's abdomen about $14\frac{1}{2}$ in in diameter. At 500 kv the charge would have been 100 mc. The man recovered.

Table 5 gives a few of the full-wave fence controller

TABLE 5. IMPULSE TESTS ON MEN

Controller Characteristics: Full-Wave Rectifier Connection

Subject No.	Peak current output, ma	Voltage	Capacity, μf	Fence capacity, μf	Shocks received
93	100	1750	2.00		4
	100	1750	2.00		2*
	125	1700	1.5		1
	150	1430	1.00		5
	150	1720	1.75		1
	75	900	1.00	0.2	1
	150	1720	1.00	0.2	1
37	50	1700	1.0		1
	50	1700	1.5		1
	100	1700	1.5		1
	125	1700	1.5		1
	150	1720	1.75		1
	100	1150	1.00	0.2	1
	150	1720	1.00	0.2	1
137	50	1700	0.5		1
	100	1700	1.5		1
	100	1750	2.0		3
	150	1430	1.0		4
	150	1700	1.75	0.2	1
132	100	1700	1.5		1
	100	1750	2.0		2
	125	1700	1.5		1
	100	1150	1.0	0.2	1
	150	1720	1.0	0.2	1

*2 V.T. half-wave rectifier connection, no difference in impulse sensation.

EDITOR'S NOTE: Table 5 has been abbreviated to conserve space.

TABLE 6. IMPULSE TESTS ON ANIMALS

Conducted in the H. Moffat Company's Slaughter House in San Francisco

Controller Characteristics: Full-Wave Rectifier Connection

Peak current output = 150 ma
Continuous current output = 15 ma
Condenser capacity = 2μf

No. of animals	Age	Est weight, lbs	Controller output, v	Fence capacity, μf	Total condenser charge, millicoulombs	Resistance of animal, ohms	Avg no. of shocks	Remarks
Spring lambs Contacts — insulated feed trough to rear feet on wet earth								
11	4-6 mo	80-90	1400	2	5.6		1	
12	4-6 mo	80-90	1400	3	7.0		1	
Spring lambs Contacts — metal electrode on lips to rear feet in bucket of salt water								
10	4-6 mo	72	1400	11	18.2	550-1750	3	
10	4-6 mo	70	1600	11	20.8	550-1750	3	3 sheep stunned for 5-15 sec*
13	4-6 mo	72	1750	10	21.0	550-1750	3	1 sheep stunned for 5-15 sec*
6	4-6 mo	72	1750	11	22.7	550-1750	2	1 sheep stunned for 5-15 sec*
Hogs Contacts — insulated feed trough to rear feet on wet earth								
1		180-200	1400	1	4.2		4	
25		180-200	1400	3	7.0		4	
1		215-225	1000	8	10.0		1	
2		215-225	1200	8	12.0		1	
1		215-225	1600	8	16.0		1	
25		215-225	1750	8	17.5		1	
1		215-225	1400	10	16.8		1	
12		215-225	1750	10	21.0		1	1 hog stunned for 60 sec*

*Animals were stunned on third or fourth consecutive shock.

and impulse tests on men. In the majority of the experiments the subjects grasped a short length of wire energized directly from the controller. The additional effect due to the charge on the fence was studied by connecting a 0.2-μf condenser across the controller terminals. Assuming the average fence to have a capacity of 0.015μf per mile, this was the equivalent of $0.2/0.015 = 13$ miles of fence wire. Larger condensers were not used because of the severity of the shock. Arrangements were made with the H. Moffat Company, wholesale butchers, to conduct tests at higher values on their animals. The results of tests on spring lambs and hogs using larger condensers are given in Table 6. As before, the charge on the fence was simulated by connecting condensers across the controller terminals. Condensers totaling 11 μf at 1750 v, the limit of the equipment, were used with no serious effects. This was equivalent to $11/0.015 = 733$ miles of fence, and a charge of 19.25 mc. A series of repeated shocks were given the spring lambs, the period between shocks being just sufficient to permit charging the condensers as evidenced by recovery of the output voltage. Five lambs and one hog were stunned for a few seconds on the third or fourth shock; however, all recovered and no further after-effects were noticed. Due to lack of apparatus, no attempt was made to coordinate the shocks with the sensitive phase of the heart cycle[8], but because of the number of shocks applied it is reasonable to suppose that they were distributed throughout the heart cycle. The results of this study indicate that there is small hazard to life due to impulse currents, and substantiate the opinion that the proposed single impulse electric fence controller and charge on the average 10 to 15-mile fence are reasonably safe.

CONCLUSIONS

1 It is impossible to design an electric fence controller which will be safe for *all* individuals.

2 The non-interrupted, a-c electric fence with a current limitation of 8 ma is believed dangerous.

3 The non-interrupted, direct-current fence with a current limitation of 15 ma is believed reasonably safe.

4 The intermittent types of electric fence controllers as approved in present regulations, although possibly safe electrically, should be considered inhumane.

5 The single impulse electric fence controller is believed to be a satisfactory and reasonably safe solution of the electric fencing problem.

6 The shock hazard from the charge on the average 10 to 15-mile electric fence wire is believed small.

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AUTHOR'S ACKNOWLEDGMENTS: The cooperation and continued interest of the subjects who volunteered for these experiments is gratefully acknowledged. Acknowledgment is given the H. Moffat Co. for the use of their animals. Acknowledgments are also due the General Electric Co., Westinghouse Electric & Manufacturing Co., Ohio Brass Co., Stanford University, and California Institute of Technology, for data regarding accidents on impulse currents. Special thanks are given the various interested persons for helpful suggestions and technical data.

Effect of Crops and Slopes on Run-off and Soil Loss

(Continued from page 398)

sity increases with slope for all slopes. The data on rates of run-off for these four storms from 1/50-acre plots failed to show such a relationship, indicating that any normal slope effect may be completely masked by uncontrolled soil or other variables even when restricted to one soil type and a radius of 75 yd. An average of these run-off data revealed a close similarity between rates of run-off from the corn plots on the 5, 20, and 25 per cent slopes but 40 per cent lower rates from the plots on the 10 and 15 per cent slopes. On the other hand, the average run-off rate from the wheat on the 10 per cent slope was about 40 per cent higher than from the other slopes.

The run-off rate curves for the individual storms emphasize the large difference in rates of run-off to be expected between close-growing and wide-spaced crops under most soil and rainfall conditions. The average 1-min peak flows from all slopes for the four storms studied were 2.96 in per hr from corn, 0.52 in per hr from wheat, and 0.12 in per hr from the hay plots. The average run-off per rain for all slopes was 0.41, 0.07, and 0.017 in from corn, wheat, and hay, respectively. The ratio between the average maximum rates of run-off from the three crops was 1:4.3:24.6 for hay, wheat, and corn, respectively. An almost identical ratio existed between the total run-offs from the same crops. The average soil loss per rain for the same storms was 2.8 tons per acre from corn, 0.11 ton per acre from wheat, and about 0.01 ton per acre from the hay plots. Thus the soil loss ratio was 1:11:280 for hay, wheat, and corn, respectively.

SUMMARY

Hydrographs and other run-off rate curves have been presented showing comparisons of run-off rates from corn, wheat, and hay plots on 5, 10, 15, 20, and 25 per cent slopes resulting from four spring and summer rains of the thunderstorm type. The data emphasize the difficulty of attempting to assign to any one factor its quantitative effect on the erosion process for any specific condition because these effects are constantly changing as a result of their interrelation with other factors.

It seems safe, however, to conclude that a close-growing crop such as wheat will prevent excessive rates of run-off from Dunmore silt loam on all slopes investigated under Virginia rainfall conditions, while high rates of run-off must be expected from corn grown on this soil; and serious soil losses result when it is planted on slopes above 10 per cent. The hay crop offered practically complete protection against run-off and erosion.

AUTHOR'S ACKNOWLEDGMENT: The author acknowledges assistance and suggestions from Charles E. Seitz, H. T. Rogers, Emanual Azar, C. M. Jones, and M. B. Rainey of the Virginia Agricultural Experiment Station, and from Jesse Elson of the U. S. Soil Conservation Service.

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NEWS

A.S.A.E. Fall Meeting at Chicago

AS USUAL in recent years, the fall meeting of the American Society of Agricultural Engineers will be held this year at the Stevens Hotel, Chicago, during the week of the International Livestock Exposition. The exact dates of the meeting are December 1, 2, and 3.

The program that is being sponsored by each of the four technical divisions of the Society—Power and Machinery, Rural Electric, Farm Structures, and Soil and Water Conservation—will be spread over the three-day period of the meeting, but at no time will there be more than two groups meeting concurrently. The purpose of this arrangement is to bring all who are interested mainly in the program of a particular division to Chicago at the same time so they will have an opportunity to attend programs offered by other divisions. This arrangement also provides more time between the sessions of any divisional group for committee meetings, individual contacts, etc.

A high light of the meeting this year will be a Society dinner on Tuesday evening, December 2. Geo. W. Kable, president of the A.S.A.E., will preside as master of ceremonies at this dinner. The principal speakers for the occasion will be Fowler McCormick, president of the International Harvester Co., and C. E. Frudden, executive engineer, tractor division, Allis-Chalmers Mfg. Co. The scheduling of this dinner is in response to many demands of members of the Society, and its purpose mainly is to provide better opportunity for those attending the meeting to renew and extend their acquaintances among members of the Society.

Following are the subjects and speakers that go to make up the program for the various sessions of the three-day meeting:

Monday forenoon, December 1. Two concurrent programs, Power and Machinery and Farm Structures. The Power and Machinery program will feature a symposium on the industrial utilization of straw and cornstalks. Scheduled speakers will be representatives of the agricultural experiment stations, the U.S.D.A., and farm machinery manufacturers.

The Farm Structures program will include a paper on current problems in farm building by F. Stuart Fitzpatrick of the U. S. Chamber of Commerce, a paper on adapting plywood to farm building construction by J. D. Long of the Douglas Fir Plywood Assn., and a talk on looking ahead to better farm buildings by K. J. T. Ekblaw, agricultural engineer, American Zinc Institute.

Monday afternoon, December 1. This period will be devoted exclusively to a program sponsored by the Committee on Research, with the cooperation of the four technical divisions of the Society, the particular feature of which will be an address, entitled "Some Agricultural and Industrial Research Parallels," by Dr. Anson Hayes, director of research of the American Rolling Mill Co. The address will be followed by prepared discussions, mainly from members of the Society representing different phases of public and industrial research, followed by general discussion. This session will be continued into the evening, when it will take the form of round table discussions on agricultural engineering research objectives and programs.

Tuesday forenoon, December 2. A joint Farm Structures and Rural Electrification program will feature a symposium on spray painting of farm buildings, on which the three scheduled speakers are L. A. Buse, supervisor of repairs, Equitable Life Assurance Society; Dr. F. L. Browne, senior chemist, U. S. Forest Products Laboratory, and Don Critchfield, Lead Industries Assn.

Concurrently with this program will be a Soil and Water Conservation program, in which two papers will be presented by A. W. Zingg, U. S. Soil Conservation Service, one on soil movement within the profile of terraced lands, and the other on terrace grades on Shelby soil as they affect soil and water losses. A paper on outlet design for terraced land by Donald Christy, assistant professor of agricultural engineering, A. & M. College of Texas, is included on this program.

Tuesday afternoon, December 2. (1:00 to 3:00 p.m.) A symposium on corn production and harvesting will be the feature of the Power and Machinery program for this period. The speakers who will contribute to this symposium include Lester J. Pfister, owner and manager of the Pfister Hybrid Corn Co., G. W. McCuen of Ohio State University, H. P. Bateman and R. F. Skelton of the University of Illinois, L. B. Neighbour of the John Deere Spreader Works, and Martin Ronning of the Minneapolis-Moline Power Implement Co.

Concurrently with this program, will be a Rural Electrification program, on which is scheduled a paper on applications of fluorescent lighting on the farm by Miss Myrtle Fahsbender, a lighting specialist of Westinghouse, and a paper on the relation of kinds of lights to attraction of night-flying insects by L. C. Porter, illuminating engineer, General Electric, based on cooperative research studies by the Ohio Agricultural Experiment Station. At this session also will be presented a report of the Committee on Farm Wiring on non-metallic cable in farm buildings.

Tuesday afternoon, December 2. (3:30 to 5:30 p.m.) Opening the Soil and Water Conservation program for this period, D. W. Cardwell, assistant agricultural engineer, U. S. Soil Conservation Service, will discuss the form for publication of hydrologic data. A paper on the effect of plant residues and cultivation on run-off and erosion from Muskingum silt loam will be presented by Dr. H. L. Borst, soil conservationist, and Russell Woodburn, associate agricultural engineer of the S.C.S. research project at Zanesville, Ohio. Discussion of this paper will be led by Francis A. Post, junior agronomist, S.C.S. research project at Coshocton, Ohio. Ray W. Carpenter, professor of agricultural engineering, University of Maryland, will explain Maryland's new public drainage law.

Concurrently with this program will be a Farm Structures program on which three papers are listed: Development of farm housing standards, by H. E. Wichers, associate professor of architecture, Kansas State College; heat transfer studies in underground storages, by A. D. Edgar, agricultural engineer, U. S. Bureau of Agricultural Chemistry and Engineering, and prevention of rural fires as a conservation measure by Henry Giese, professor of agricultural engineering, Iowa State College.

Tuesday evening, December 2. The A.S.A.E. dinner, previously referred to, is scheduled for 7.00 p.m. Tickets will be $2.50.

Wednesday forenoon, December 3. A joint Power and Machinery and Soil and Water Conservation program will feature a symposium on the subject "Surface Mulching in Relation to Soil and Moisture Conservation and Machinery Problems." Dr. H. H. Bennett, chief, U. S. Soil Conservation Service, will be the first speaker, and his paper will be discussed by Dr. R. E. Yoder of the Ohio Agricultural Experiment Station. L. W. Chase, a charter member of A.S.A.E., and president of the Chase Plow Co., will discuss his company's experience in the development of machinery for subsurface tillage, and Dr. F. L. Duley, senior soil conservationist, U. S. Soil Conservation Service, will discuss the experiences of his staff with various equipment for subsurface tillage. Other speakers on this program include H. A. Morehead, International Harvester Co., and John P. Seaholm, Minneapolis-Moline Power Implement Co.

Concurrently a Rural Electrification program includes a paper on problems in 4-H mechanical club work by R. A. Turner, senior agriculturist, U.S.D.A. Extension Service, and a paper on the small batch electric milk pasteurizer by Geo. J. Burkhardt, agricultural engineer, University of Maryland. In addition, there will be a demonstration of recent developments in electric circuit breakers and fuses by A. A. Sommer of the Bussman Mfg. Co.

Wednesday afternoon, December 3. (1:00 to 3:00 p.m.) A Farm Structures program is scheduled for this period and will feature the subject of grain storage. The program will open with a paper on recent grain storage developments by H. J. Barre and C. F. Kelly, agricultural engineers, U. S. Department of Agriculture. In addition to this there will be a symposium on new types of low-cost grain storages which will be discussed by LeRoy Carr of the Rilco Laminated Products Co., R. A. Glaze of the Weyerhaeuser Sales Co., F. C. Fenton of Kansas State College, and D. H. Malcom of American Rolling Mill Co.

At the close of this program, a Rural Electrification program, from 3:30 to 5:30 p.m., will be presented and will include a

A.S.A.E. Meetings Calendar

December 1 - 3—Fall Meeting, Stevens Hotel, Chicago.

January 14 - 15—Pacific Coast Section, Davis, Calif.

February 4 - 6—Southern Section, Gayoso Hotel, Memphis, Tenn.

June 22 - 25—Annual Meeting, Hotel Schroeder, Milwaukee.

paper on radiation in agriculture by J. P. Ditchman, illuminating engineer, General Electric Company, and a paper, entitled "New Engineering and a New Industry in the Agricultural Field," by M. M. Samuels, chief, technical standards division, Rural Electrification Administration.

Concurrently with the above two programs will be a Power and Machinery program (2:00 to 5:00 p.m.) on which is listed a paper devoted to the results of a study of combine power requirements by C. G. E. Downing, agricultural engineer of the Dominion Experimental Station (Canada), and a paper on tractor stop hitches by A. W. Clyde, professor of agricultural engineering, Pennsylvania State College. In addition the Committee on Hay Handling and Storage will have a contribution for this program on some pressing problems in equipment for hay handling.

In addition to the program outlined, there will also be a number of committee and other group round table meetings, announcements of which will be made both previous to and during the meeting sessions.

At all sessions of the A.S.A.E. meeting non-members as well as members of the Society will be welcome.

Agricultural Engineering Research

AN INTERESTING review of research in agricultural engineering carried on by the state agricultural experiment stations, some of it in cooperation with various bureaus of the U. S. Department of Agriculture, appears in the 1940 U.S.D.A. report on the agricultural experiment stations. The review is prepared by Dr. R. W. Trullinger, assistant chief, Office of Experiment Stations, and is available in reprint form through the Government Printing Office in Washington. Every agricultural engineer will be interested in the progress of agricultural engineering research as reported in Dr. Trullinger's review.

Minnesota Research Ag Engineers Meet

ON SEPTEMBER 24, the experiment station staff members of the Division of Agricultural Engineering at the University of Minnesota Farm met in St. Paul for a conference with agricultural engineers and superintendents from each of the branch experimental stations in Minnesota. The purpose of the conference was to discuss mutual problems and to enable each station to become better acquainted with the experimental work in progress at the other stations. Primarily research in progress at the central station was discussed.

Since this meeting was found to be quite worth while, it was decided that it should inaugurate a series of similar conferences to be held annually. In 1942 the group will convene at the West Central Experiment Station at Morris. The stations represented at the conference were the Central Experiment Station at St. Paul, the Northwest station at Crookston, the West Central station at Morris, the North Central station at Grand Rapids, the Northeast station at Duluth, and the Southeast station at Waseca.

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Forrest O. Beardmore, junior agricultural assistant, Soil Conservation Service, U. S. Department of Agriculture. (Mail) 808 Madison St., Bedford, Iowa.

Clifford D. Cannon, junior soil conservationist, Soil Conservation Service, U. S. Department of Agriculture. (Mail) Hemingway, S. C.

Alvin C. Dale, research fellow, agricultural engineering department, Iowa State College, Ames, Iowa.

Arlon G. Hazen, instructor, agricultural engineering department, University of Arkansas, Fayetteville, Ark.

Ben Hibbs, editor, "Country Gentleman", The Curtis Publishing Co., Philadelphia, Pa.

James E. Payne, junior soil conservationist, Soil Conservation Service, U. S. Department of Agriculture. (Mail) RR No. 1, Hartwell, Ga.

A. W. Scarratt, vice-president, International Harvester Co. (Mail) 521 Kenilworth Ave., Kenilworth, Ill.

Tom E. Tierney, experimental department, Dain Mfg. Co., Ottumwa, Iowa. (Mail) Y.M.C.A.

Student Branch News

Active Branches. Up to the time this issue of AGRICULTURAL ENGINEERING went to press, the membership lists and branch dues for the current school year of the following A.S.A.E. Student Branches had been received by the Secretary of A.S.A.E., in the order named: Georgia, Florida, Minnesota, Texas, Kansas, and Michigan.

TEXAS

By W. Tip Hall, Jr., Scribe

THE A.S.A.E. Student Branch at the A. and M. College of Texas started its year's activities soon after the beginning of the fall term. The officers, elected last spring, met several days before the first scheduled meeting and appointed the standing committees for the year. Immediately afterwards the membership committee began contacting all agricultural engineers urging them to come out to the first meeting. Written invitations were sent to all new students.

The first meeting was held on September 23. Each member of the faculty spoke on some phase of agricultural engineering. "The History of the A.S.A.E." and "How to Improve Our Student Branch" were discussed by Prof. F. R. Jones and Prof. F. W. Peikert, respectively. Opportunities after graduation in several fields of agricultural engineering were discussed by the other members of the Department. Prof. Donald Christy spoke on soil and water conservation. Farm buildings and home utilities were covered by Prof. Price Hobgood, and W. E. McCune spoke on farm power and machinery.

A short business session preceded the program, and at that time each member was given a mimeographed sheet outlining the parliamentary procedure to be followed at all meetings. Since a large number of new students were present, each person gave his name, campus address, and home town when the meeting was first called to order.

The second meeting was a picnic held after class on October 2. Under the leadership of the social committee, the picnic was a great success as a large number of students were present. Football and baseball teams were organized and games were followed by a grand feast. A short business session concluded the day.

The purpose of the annual fall picnic is to bring freshmen and upperclassmen in closer contact with each other—and make the new students realize the advantages of becoming affiliated with the Branch. When the freshmen returned to their dormitories, it was quite evident that the purpose of the picnic had been accomplished.

GEORGIA

By T. F. Lumsden, Scribe

PROF. R. H. DRIFTMIER, head of the department of agricultural engineering, called a meeting of all agricultural engineering students at the beginning of the fall quarter, the chief purpose of which was to welcome all of the new students. All members of the faculty and the president of the Georgia Student Branch of the A.S.A.E. were presented to the group.

The president, O. W. Ginn, called on each Branch officer to speak a word of welcome to the freshmen and transfers. The officers of the Branch for the fall quarter are O. W. Ginn, president; Clyde Mize, vice-president; D. L. Payne, secretary; T. F. Lumsden, scribe; C. B. Seckinger, editor of the Georgia Ag Engineer; Harold Fletcher, business manager of Ag Engineer, and treasurer of the Branch, with Prof. W. N. Danner as faculty advisor.

Our first regular meeting of the school year was held October 13, the speaker for the evening being Mr. Paul W. Chapman, dean of the college of agriculture of the University of Georgia. Dean Chapman spoke on "War and Agriculture in Georgia". One of the interesting things that he mentioned was that the U. S. Department of Agriculture is asking the State of Georgia to increase its peanut acreage next year by 50,000 acres. Dean Chapman also stated that an increased production of dairy products, livestock, and poultry was requested, not only in Georgia, but in all states.

A business session followed Dean Chapman's talk. The Branch voted to sponsor a dance Friday night, October 24. Since it will be the first one held on the campus this quarter we are looking forward to a successful dance.

So far the Branch has enrolled twenty-six new members and thirty-four old members. We are proud of this large membership, and are especially proud of one outstanding member, E. T. Mims, who was elected president of the National Council of Student Branches of the A.S.A.E. at the annual meeting at Knoxville last June.

A.S.A.E. Organization — 1941-42

OFFICERS AND COUNCIL

Geo. W. Kable - - - - - - - - *President*
E. E. Brackett - - - - - - - *Past-President*
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National Fire Protection Association — Henry Giese, W. G. Kaiser, J. F. Schaffhausen

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Joint Committee on Hydrology (Section of Hydrology, American Geophysical Union and A.S.A.E. cooperating) — H. S. Riesbol, F. E. Staebner, R. Earl Storie

Joint Committee on Measurement of Soil Tilth (American Society of Agronomy and A.S.A.E. cooperating) — I. F. Reed, M. L. Nichols, B. A. Jennings

Joint Committee on Poultry Housing (Poultry Science Association and A.S.A.E. cooperating) — M. A. R. Kelley, J. L. Strahan, L. L. Sammet, J. C. Wooley

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Agricultural Engineering Digest

A review of current literature by R. W. TRULLINGER, assistant chief, Office of Experiment Stations, U. S. Department of Agriculture. Copies of publications reviewed may be procured only from the publishers at the addresses indicated.

THE SLOTTED-TEMPLET METHOD FOR CONTROLLING MAPS MADE FROM AERIAL PHOTOGRAPHS, *H. T. Kelsh.* U. S. Dept. Agr. (Washington), Misc. Pub. 404 (1940), pp. 30, figs. 22. Methods for the accurate mapping from aerial photographs of areas in which ground-control points are few and widely separated are here discussed. The earlier or hand-templet method consisted in transferring to a transparent templet (film of cellulose acetate or nitrate) the principal point of each photograph, together with lines radial to the principal point and passing through the image points located on the photograph. These templets were so assembled that all the radials common to each identified position intersect, the intersection being the true location of the point. Distortion of the transparent templets by humidity and temperature changes was found considerable. Limitations in the possible accuracy of the drafting introduced further error. It is also pointed out that, if tilt is present, the radials will not intersect but will form triangles of error, and the elimination of these is a matter requiring considerable experience and, at the best, is largely a matter of personal judgment and compromise. In the slotted-templet method the radial line on the templet is replaced by a radial slot, in which a close-fitting round stud is inserted, free to slide along the longitudinal axis of the slot. The slot takes the place of the line. The templet material need not be transparent, therefore, and can be made of stiff material not subject to the distortion of the flexible cellulose ester sheets used for hand templets. The rigidity of templet material permits the laying of all of the templets having cuts to the same common point over the stud representing that point. The stud and the templets being of rigid material, motion is possible only along the longitudinal axes of the slots. The templets therefore tend to adjust themselves into theoretically perfect positions. A hand cutter for slotted templets and a more elaborate machine, capable of being set to change scale automatically so as to cut templets to any scale between one-half that of the photograph and twice that of the photograph, are briefly described.

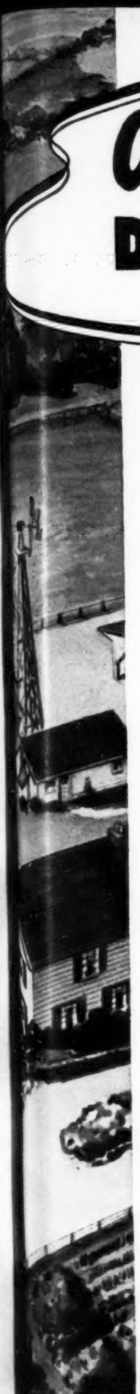
Tests at Beltsville, Md., and elsewhere indicated that the limitations of the system would not prevent its use in making an aerial planimetric map of any portion of the United States, using only the existing control and the type of photographs at present available.

TERRACE CONSTRUCTION WITH SMALL EQUIPMENT IN THE SOUTH, *W. A. Weld and P. M. Price.* U. S. Dept. Agr., Soil Conserv. Serv., 1940, pp. 11, figs. 6. It is pointed out that the drainage or channel-type terrace is the most satisfactory for runoff control. The construction of such terraces by means of the plow and scraper, plow and V-drag, one-way disk tiller, and the small-blade terracer or grader is briefly discussed and is illustrated by photographs and diagrammatic drawings.

ELECTRIC MOTORS FOR THE FARM, *H. L. Garver, O. A. Brown, J. T. Bowen, and R. B. Gray.* U. S. Dept. Agr. (Washington), Farmers' Bul. 1858 (1940), pp. [2]+29, figs. 17. Following a brief introduction dealing with advantages over other sources of stationary power, this publication defines, in a manner intended to be clear to readers without technical knowledge of electric power, some necessary electrical terms; and proceeds to brief, partial descriptions of the split-phase, repulsion-induction, capacitor, and universal types of the single-phase motor. Selection of the type of motor best suited to a given set of power requirements is taken up, together with the care of motors. A tabular listing of motor troubles, indicating, in parallel columns, symptom, cause, and remedy, is included, as are also suggestions concerning mounting of motors, types of drive, pulleys and pulley ratios, and motor control and protection. A popular explanation of the fundamental principles of electric motors concludes the publication.

SUPPLEMENTAL IRRIGATION, *F. E. Staebner.* U. S. Dept. Agr. (Washington), Farmers' Bul. 1846 (1940), pp. [2]+74, figs. 42. The most important of the numerous varieties of possible equipment are here discussed. Under the head of water supply are taken up quality, quantity, surface supplies, stream measurements, use of small and flash-type streams, underground and municipal water supplies, and legal requirements. The various available pumps and power outfits are dealt with in similar detail, as are also transportation, distribution, determination of the proper time for irrigation, choice of equipment, and plant-design information. This publication supersedes Farmers' Bulletins, 1529 and 1635 respectively concerned with spray irrigation, and with surface irrigation, in the eastern states. *(Continued on page 416)*

Agricultural Engineers
DESIGN IMPLEMENTS OF DEFENSE



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Agricultural Engineering Digest

(Continued from page 414)

Agricultural Engineering Investigations at the South Dakota Station. South Dakota Agrl. Exp. Sta. (Brookings) Rpt. 1940, pp. 63-66, fig. 1. These have included work on the feasibility of rubber tires for farm vehicles, by H. H. DeLong; redesigning of horse-drawn equipment for tractors, by L. F. Larsen, DeLong, and R. L. Patty; further studies on rammed-earth construction, by Patty, H. M. Crothers, and DeLong; comparative tests of galvanized and painted steel fence posts, by Patty; tests of hard-surfaced floors for poultry houses, by Patty and Larsen; and an investigation of the causes of mechanical injury to barley, by DeLong and Larsen (coop. N. Dak. and Minn. Expt. Stas. et al.)

Agricultural Engineering Operations and Investigations of the U. S. Department of Agriculture. U. S. Dept. Agr. (Washington), Sec. Agr. Rpt., 1940, pp. 137-141, 160-162. The work of the Rural Electrification Administration is briefly reported upon, together with various engineering investigations noted under the heads of agricultural engineering and machinery and small-scale farming.

New Literature

"Farm Buildings," by John C. Wooley (Member A.S.A.E.), professor of agricultural engineering, University of Missouri. First edition. Cloth, 6x9 in, 340 pages, 212 figures. $3.00. McGraw-Hill Book Co., Inc., New York. This book is a development of class and lecture notes used by the author in his classes at the University of Missouri, and is intended for use primarily as a textbook. The book will also be found valuable to farm managers, appraisers, county agents, vocational teachers, and farm operators, who are confronted with problems relating to structures. The book is divided into nine parts. Part 1 is general and Part 2 deals with the various building materials including siding, roofing, and insulation. Part 3 covers structural design, including barn frames, design of beams and columns, and roof framing. Part 4 is on air conditioning in its various aspects. Part 5 deals with livestock and poultry buildings, and Part 6 with buildings for storage of crop and equipment. Part 7 covers management of buildings, including repair and remodeling, appraisal, and location and planning the farmstead, etc. Part 8 deals with the planning and design and construction of the farm home, and with modern facilities for the home. Part 9 deals with drafting and the interpretation of plans.

EMPLOYMENT BULLETIN

The American Society of Agricultural Engineers conducts an employment service especially for the benefit of its members. Only Society members in good standing may insert notices under "Positions Wanted," or apply for positions under "Positions Open." Both non-members and members seeking to fill positions, for which ASAE members are qualified, are privileged to insert notices under "Positions Open," and to be referred to members listed under "Positions Wanted." Any notice in this bulletin will be inserted once and will thereafter be discontinued, unless additional insertions are requested. There is no charge for notices published in this bulletin. Requests for insertions should be addressed to ASAE, St. Joseph, Michigan.

POSITIONS OPEN

AGRICULTURAL ENGINEER wanted for farm structures research work in the agricultural experiment station of a southeastern college. Only a man with some research experience and not subject to immediate military service will be considered. Work will be primarily concerned with storage buildings. Good fundamental training with good scholastic records necessary. Salary up to $2,700 according to qualifications. PO-134

POSITIONS WANTED

AGRICULTURAL ENGINEER, also farm and supply manager, has had 20 years' experience in agricultural pursuits as manager of large farming enterprise and agricultural supply house, and as chief agricultural engineer of large irrigation development in the West. Has had technical training and practical experience in all phases of engineering and agricultural production, development, and marketing. Best of references. Forty-four years of age. Married. PW-341

AGRICULTURAL ENGINEER with 15 years' experience in the farm equipment industry; knows both farmer and tractor and implement industry in all sections of world; especially Canada and U.S.; advertising, public relations, editorial, camera, radio; can direct a complete service for dealers and factory; knows governmental and agricultural college officials; Farm Bureau; boys' and girls' clubs, livestock and special crop associations. Will locate anywhere the right firm or industry may wish. Have production records that speak. Personal portfolio mailed on request. PW-343